CHALMERS
UNIVERSITY OF TECHNOLOGY

Enhancing Client Value Through Digital Solutions in Construction Project Management

A Study of the Construction Phase

Master's thesis in Design and Construction Project Management

IDA GRANATH & TOVA INGESSON

DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2025
www.chalmers.se

Master's thesis 2025

Enhancing Client Value Through Digital Solutions in Construction Project Management

A Study of the Construction Phase

IDA GRANATH
TOVA INGESSON

Department of Architecture and Civil Engineering
Division of Construction Management
Chalmers University of Technology
Gothenburg, Sweden 2025

Enhancing Client Value Through Digital Solutions in Construction Project Management
A Study of the Construction Phase

IDA GRANATH
TOVA INGESSON

Supervisor: Mikael Viklund Tallgren, Department of Architecture and Civil Engineering
Examiner: Mikael Viklund Tallgren, Department of Architecture and Civil Engineering

Master's Thesis 2025
Department of Architecture and Civil Engineering
Division of Construction Managemen
Chalmers University of Technology
SE-412 96 Gothenburg
Telephone +46 31 772 1000

Typeset in LaTeX
Printed by Chalmers Reproservice
Gothenburg, Sweden 2025

Enhancing Client Value Through Digital Solutions in Construction Project Management
A Study of the Construction Phase
IDA GRANATH
TOVA INGESSON
Department of Architecture and Civil Engineering
Chalmers University of Technology

Abstract

Despite a long history of construction, the industry continues to face challenges such as high costs, low productivity, and difficulties in delivering affordable, high-quality buildings to the clients. Digitalization offers solutions to many of these problems by improving communication, coordination, and decision-making across the project lifecycle. This master thesis investigates how digital solutions can be utilized by construction project managers during the construction phase, to create value for the client. An initial literature study was conducted to examine the current state of digitalization in the construction industry. Based on this, a qualitative interview study was held with construction project managers, clients, and digitalization experts. Based on their experiences, recurring challenges such as communication, coordination, model handling, and documentation during the production phase were identified. The study analyzes how Common Data Environments (CDE:s) can address these issues through targeted features and workflows. The master thesis also focuses on the integration of complementary technologies, such as 360-degree cameras, to enhance documentation and site monitoring. The findings highlight how CDE:s can centralize project communication, reduce information loss, and improve decision-making by clients. The use of Building Information Models (BIM) with status codes facilitates accurate progress tracking and early detection of delays. Key client benefits include fewer construction errors, minimized cost and time overruns, and improved documentation for the operational phase. A high-quality BIM model supports long-term facility management and sustainability efforts. For construction project managers, digital platforms offer tools to manage issues, document site visits, and monitor the time plan in real time. Despite these benefits, several barriers to implementation remain, including organizational resistance, cost, licensing, and training needs. The study concludes that digital platforms have the potential to increase client value during the construction phase. However, full realization of these benefits requires early and continuous digitalization from the design stage and active involvement of all stakeholders.

Keywords: Construction project management, Client value, Building Information Model (BIM), Common Data Environment (CDE), Digital solutions

Öka kundvärdet genom digitala verktyg inom byggledning
En studie av produktionsfasen
IDA GRANATH
TOVA INGESSON
Department of Architecture and Civil Engineering
Chalmers University of Technology

Sammanfattning

Trots en lång historia av byggnation står branschen fortfarande inför utmaningar såsom höga kostnader, låg produktivitet och svårigheter att leverera prisvärda, högkvalitativa byggnader till beställare. Digitalisering erbjuder lösningar på många av dessa problem genom att förbättra kommunikation, samordning och beslutsfattande under projektets livscykel. Detta examensarbete undersöker hur digitala lösningar kan användas av byggledare under produktionsfasen för att skapa värde för beställaren.

En inledande litteraturstudie genomfördes för att undersöka nuläget kring digitalisering i byggbranschen. Baserat på detta genomfördes en kvalitativ intervjustudie med byggledare, beställare och digitaliseringsexperter. Utifrån deras erfarenheter identifierades återkommande utmaningar såsom kommunikation, samordning, modellhantering och dokumentation under produktionsfasen. Studien analyserar hur Common Data Environments (CDE:er) kan adressera dessa problem genom dess funktioner.

Examensarbetet fokuserar även på integrationen av kompletterande teknologier, såsom 360-graderskameror, för att förbättra dokumentation och platsövervakning. Resultaten lyfter fram hur CDE:er kan centralisera projektkommunikation, minska informationsförluster och förbättra beställarens beslutsfattande. Användningen av Building Information Models (BIM) med statuskoder möjliggör korrekt uppföljning av framdrift och tidig upptäckt av förseningar. Viktiga fördelar för beställaren inkluderar färre byggfel, minskade kostnads- och tidsöverskridanden samt förbättrad dokumentation för förvaltningsfasen. En högkvalitativ BIM-modell stödjer långsiktig fastighetsförvaltning och hållbarhetsarbete. För byggledare erbjuder digitala plattformar verktyg för att hantera avvikelser, dokumentera platsbesök och följa tidplanen i realtid. Trots dessa fördelar kvarstår flera hinder för implementering, inklusive organisatoriskt motstånd, kostnader, licenshantering och utbildningsbehov. Studien drar slutsatsen att digitala plattformar har potential att öka beställarvärdet under produktionsfasen. För att fullt ut realisera dessa fördelar krävs dock tidig och kontinuerlig digitalisering från projekteringsfasen samt aktivt deltagande från alla intressenter.

Nyckelord: Byggledning, Beställarvärde, Building Information Model (BIM), Common Data Environment (CDE), Digitala lösningar

Acknowledgements

This master's thesis marks the conclusion of five intense, inspiring, and rewarding years of studies at the Civil Engineering program at Chalmers University of Technology. The time for completion of this thesis has been a journey filled with great opportunities to explore how the construction industry can take steps forward by using digital solutions.

We would like to express special gratitude to WSP and the department Project Management Väst for showing interest in our thesis and for welcoming us so warmly. A big thank you to our supervisor Niclas Carnebratt, whose support, engagement, and expertise have been key to the success of this project. A special thanks goes to Kristian Sjöstedt at WSP, for setting us off in the right direction early on, and for generously sharing your knowledge and network with us.

We are also very grateful to our academic supervisor and examiner, Mikael Viklund Tallgren from Chalmers University of Technology, for his support, feedback, and guidance throughout the process.

Finally, we want to sincerely thank all the construction project managers, clients, and digitalization experts who took the time to speak with us during interviews. Your input gave this thesis real depth and made it both insightful and enjoyable to work on.

Thank you all, and many more. This master's thesis would not have been complete without you.

Ida Granath & Tova Ingesson, Gothenburg, June 2025

Acronyms

Acronyms	**English**
ACC	Autodesk Construction Cloud
AEC industry	Architecture, Engineering, and Construction industry
API	Application Programming Interface
AR	Augmented reality
CDE	Common Data Environment
CPM	Construction Project Management
CMC	Construction Management Companies
DT	Digital Twin
IFC	Industry Foundation Classes
RFI	Requests For Information
VR	Virtual reality

Contents

List of Figures

List of Tables

1
Introduction

This chapter provides a brief background to the construction industry, including its current challenges and the role of digitalization, leading up to the aim of this thesis and the formulation of the research questions. The chapter also outlines the limitations and contextual framework of the study.

1.1 Background

Despite our long history of construction, the industry has continued to struggle with challenges like high costs, low productivity, and difficulties in delivering affordable, high-quality dwellings (Hermansson & Song, 2024). Over the years, there have been improvements, but the construction industry remains hindered by its complex project-based structure, fragmented workflows, and heavy information flow. Information is often controlled by a single individual or department and rarely shared with others, resulting in poor communication and coordination, and if the construction management process is inadequate, it can negatively impact the overall success of the construction project (Nie, 2024). This lack of integration, coupled with limited digital adoption, leads to delays, cost overruns, and rework, problems faced by construction projects worldwide (Hermansson & Song, 2024).

The construction industry's digital maturity is notably low compared to other sectors. A report from Agarwal et al., 2016 reveal that construction is the second least digitalized industry globally, ranking just above agriculture and hunting. While industries like manufacturing have embraced digital solutions to produce higher-quality products at lower costs and with faster production times, construction lags behind. Construction project management remains heavily manual, with studies indicating that nearly one-third of a project manager's time is spent on non-value-adding tasks such as searching for information and documents. There is a clear need for centralized platforms that streamlines collaboration across all project phases, from planning to facility management, ensuring a transparent, efficient, and traceable flow of information (Udokwu et al., 2021).

Digitalization offers a powerful solution to many of these long standing challenges. Digital technologies can improve communication and information management. Hermansson and Song, 2024 points out that improved digitalization and usage of more new technology can reduce the risk of errors, improve communication, and speed up the decision making process. New technologies such as BIM, digital twins, and data-driven project management are helping break down information silos and enable more integrated, efficient workflows. The introduction of digital tools allows for real-time information sharing, improved decision-making, and greater collaboration between stakeholders, transforming how construction projects are managed, designed and build (Nie, 2024). Clients are important enablers for this new way of working. They have the money and the possibility to set digital requirements (Lindahl & Ryd, 2007). Digital solutions can help construction project managers and clients gain a real-time overview of project status, reducing time and improve the overall project outcome (Hermansson & Song, 2024).

The growth of digital technologies also comes with challenges related to the implementation. Organizations often struggle to adopt and fully utilize new tools, and the large number of available solutions can create confusion. The shift toward digitalization requires a fundamental change in how organizations operate, demanding new strategies for managing information and developing digital competence (Marnewick & Marnewick, 2022).

As construction projects grow more complex and demands for sustainability and resource efficiency increase, the industry must find new ways of working. Digitalization is key to overcoming challenges, closing the productivity gap, and building smarter, faster, and more sustainably than before (Hermansson & Song, 2024). The future of construction will be affected of how effectively the industry can capture digital solutions to meet these demands.

1.2 Aim and Objectives

The aim of this study is to explore how digital solutions can be utilized by construction project managers to generate value for clients during the construction phase of a project. Although the primary focus is on the construction phase, the transitions from design to facility management are also addressed, as minimizing information loss across project phases is crucial for effective digitalization.

1.3 Research questions

To support the aim of the study, the following research questions have been developed. These questions focus on the use of digital solutions by construction project managers and their potential to enhance client value during the construction phase.

- How can construction project managers utilize digital tools?
- How can client value increase during the construction phase by using digital solutions in the construction project management team?

1.4 Context of the Study

This master thesis is conducted in collaboration with the Project Management department at WSP's Gothenburg office. WSP is an international engineering and professional services consultancy firm, employing around 4,000 people in Sweden and approximately 73,900 globally. The company is listed in Canada and operates across more than 100 sectors, including energy, housing, infrastructure, and security. With ongoing projects across all continents, WSP is active in a wide range of markets and contexts.

As part of its current strategic cycle, WSP has identified several high-growth areas looking ahead to 2027. Among these are "Digital Offering" and "Project & Program Management," indicating a clear focus on developing digital tools and efficient project execution methods. These priorities align with the broader organizational aim of establishing WSP as a leading global brand within professional services, built on the contributions of engineers, scientists, and advisors.

The Project Management department at WSP in Gothenburg focuses primarily on construction project management, providing a range of services aimed at supporting clients throughout the planning and execution phases of construction projects. The department is involved in both public and private sector projects, varying in size and complexity, and operates mainly within the Gothenburg region. Project and program management has long been important to WSP's operations, with a focus on delivering projects that meet objectives and maintain a high standard of quality. The construction project management team at WSP in Gothenburg aims to support clients by delivering reliable project execution. The department for construction project management provides services such as coordination, quality assurance, environment management, and cost monitoring.

1.5 Limitations

WSP represents the clients during the construction phase. As a result, this study will focus exclusively on examining digital solutions that create value for the client and the construction project management team. Digital tools that provide benefits solely to contractors during the construction phase will not be investigated in the scope of this study. In addition, the benefits in the design phase will not be examined, as this stage of construction projects is more digitalized. Since the project management department at WSP primarily works with Swedish projects, the research will be approached from a Swedish perspective. However, the literature review will not be limited exclusively to Swedish cases, but articles from countries with significantly different conditions for digitalization will be excluded to maintain relevance.

2
Theoretical Framework

This chapter presents an overview of the current research related to the research questions of this master's thesis. The aim is to create a basis for the analysis and to give the readers a comprehensive understanding of the subject before entering the results, analysis and discussion.

2.1 Construction Project

The construction sector is project-based, meaning that most work in the industry is organized around temporary, unique projects rather than continuous, repetitive processes. Each construction project is typically independent, with a defined start and end, specific goals, and a dedicated team assembled for that particular project (Sears, 2015).

The development of a construction project in Sweden consists of four phases. In the design phase the focus is on creating detailed plans, involving architects and engineers from various disciplines (Boverket, 2021). Information about the construction is also added during this stage, which often leads to the creation of a BIM model (El Mounla et al., 2023). During the construction phase, the project is executed according to the design and specifications (Boverket, 2021). Digital tools are used to manage the field data and documentation (Spencer, n.d.). After the handover, the operation and maintenance stage begins and clients can benefit from the facility. The maintenance focus on facility management to preserve the structure's functionality and performance over time (Atkin & Bildsten, 2017).

2.2 Project Management

In PMBOK® Guide 7th Edition, project management is defined as *"The application of knowledge, skills, tools, and techniques to project activities to meet project requirements. Project management refers to guiding the project work to deliver the intended outcomes. "* (Project Management Institute, 2021). A project manager in construction is responsible for planning, coordinating, and controlling a construction project from start to finish. Project management in the construction sector is a complex process where the project manager serves as a central figure, responsible for organizing resources, communicating with stakeholders, and ensuring the project is successfully delivered within the defined constraints. The project manager in the construction industry must also manage materials and equipment, as well as people, stakeholder interactions, and the relationships between various project resources. These objectives should not only focus on short-term success, such as meeting immediate deadlines and budgets, but also on long-term success, ensuring that the project ultimately fulfills its intended purpose (Walker, 2015).

2.2.1 Construction Project Managers

If there is a need for project management competence in the client organization, the client can outsource project management to a consulting firm. The project management consulting firms have the responsibility to ensure that the right products are delivered as defined by the client and the end user (Lindahl & Ryd, 2007). In the role of a construction project manager, in a consulting company, the consultant represents the client and ensures that their goals and requirements are met (WSP, n.d.). Their primary responsibility is to oversee day-to-day operations and ensure efficient project execution. By monitoring and coordinating the construction phase of a project, the construction project manager helps ensure that the project meets schedules, budgets, and quality requirements. Construction project managers are directly involved in construction and follow-up activities on-site, acting as the clients eyes and ears during the construction phase. However, the exact role of a construction project manager can vary significantly depending on the form, scale, and specific circumstances of the project (Carnebratt, 2025).

2.2.2 Clients

The client or the project owner is the key stakeholder who initiates a construction project, either for their own use or on behalf of others. As the main driving force behind the construction process, the client plays a crucial role in steering the project and influencing its outcome. According to Lindahl and Ryd, 2007 an active and engaged client can significantly improve project success by clearly defining their needs and requirements throughout the process. Clients set the framework for the project by specifying functional, aesthetic, and technical demands for the building. The evolving nature of client organizations emphasizes the importance of well-defined objectives, especially given the growing complexity of construction projects and their alignment with economic, social, and environmental sustainability goals. More advanced construction work and fast-moving technology make the project even more complex. Legally, the client is responsible for financing the project and ensuring that all legal requirements are fulfilled. Regulations also reinforce the client's formal responsibility for the final product, making it essential for them to communicate their needs effectively. However, the variety of client types, ranging from private individuals to public organizations results in diverse needs and expectations, which the construction industry must interpret and address to deliver satisfactory outcomes (Walker, 2015).

2.2.3 Contracts

There are two main types of contracting models that a client can choose from, design-build and design-bid-build contracts (Boverket, 2024a). In design-build contracts a primary contractor is responsible for both the design and construction of the project. The primary contractor holds full responsibility for the project, ensuring that it meets the functional requirements specified by the client. In design-bid-build contracts the client is responsible for the design phase. The client then enters into an agreement with a primary contractor, who may either carry out the work independently or subcontract parts of it. Subcontractors may further engage other subcontractors. However, only the primary contractor is typically accountable to the client (Boverket, 2024a).

The procurement method describes how the client chooses to structure contracts with one or more contractors. In Sweden, two main procurement methods are commonly used: multiple prime contracts and general contracting. With multiple prime contracts, the client enters into individual agreements with several contractors and typically handles site coordination themselves. Under a general contracting model, the client hires a single main contractor who is then responsible for engaging and coordinating subcontractors (Boverket, 2024b).

2.2.4 Client Value

The concept of value has become increasingly significant in the construction industry, with studies exploring it from the perspectives of various stakeholders. Despite this, there is still no universally accepted definition of value within the sector (Oke & Aigbavboa, 2017). Project owners and clients often equalize value with cost, focusing primarily on economic factors in project delivery. However, value is more closely tied to functionality and encompasses the entire life cycle cost of a project, instead of only the transaction cost. The value of a project represents a balance between function, quality, cost, time, and other measures of project performance. Value is not limited to a single measure but relates to the overall project performance in relation to its objective or target goal (Oke & Aigbavboa, 2017). Research also place greater emphasis on factors such as reliability, client focus, and partnership development, recognizing the growing importance of collaboration and relationship-building in value creation (Aliakbarlou et al., 2017). According to research, client value can be divided into terminal and instrumental values. Terminal values encompass traditional goals such as time, cost, and quality. Instrumental values, on the other hand, emphasize the processes required to achieve these goals, including communication, collaboration, and problem-solving (Aliakbarlou et al., 2018).

Client value and quality are closely related concepts but what a client considers valuable in a product or service does not always equate to quality. Value is a dynamic and subjective concept, defined by the balance between the total benefits and sacrifices associated with a product or service. It reflects how well the offering meets client needs relative to costs or other trade-offs. Client value is shaped by the goals and expectations, which means that perceptions of value can vary between clients and organizations. What one client views as valuable may not align with another company's perspective. Quality, by contrast, is more static and objective. It refers to how well a product or service meets specific requirements and expectations (Aliakbarlou et al., 2017).

According to PMBOK® Guide 7th Edition, delivering value to stakeholders is a fundamental principle of project management. The PMBOK Guide defines value as the benefit, outcome, or usefulness that a stakeholder perceives from the delivery of project outputs. Therefore, the value of the client is not only about the product or service delivered but also about the actual value it creates for the client within their specific context. The seventh edition emphasizes a value-driven approach to project management, where the project's purpose and objectives should always be aligned with the expected value for the client and other stakeholders. This means that project managers should actively seek to understand client needs, prioritize outcomes that create the most impact, and adapt planning and delivery to maximize perceived value (Project Management Institute, 2021).

Non-value-adding activities refer to actions within the construction process that consume time, money, or resources without delivering any real value to the customer or project outcome. From a client perspective these activities should be eliminated wherever possible, however, research shows that nearly 50% of time in construction projects may be spent on such wasteful activities. Non-value-adding activities not only increase project costs but also reduce efficiency and stakeholder satisfaction. Since all participants in a construction project can contribute to or prevent these inefficiencies, they must be addressed through improved planning, clear communication, and effective process management (Ismail & Mohd Yusof, 2016). Digitalization plays a key role in reducing non-value-adding activities, particularly by streamlining information flows within the supply chain. Digital tools also reduce the overall workload, minimize wasted time and operational costs, and reduce human errors by ensuring more reliable and transparent data handling (Liu & Charmaine Chua, 2016).

2.3 Information Flow

Due to the construction industry's project-based structure, managing information, communication, and collaboration can be highly complex. The construction sector handles a large amount of information from various stakeholders throughout the construction process and different fields of construction use different tools for handling data. Information is generally understood as processed data that enhances knowledge, awareness, and skills, and it can exist in many different forms. Information is to an extend based on unstructured information like meetings and email-threads, that can be hard to collect. In the construction industry, data can be collected on aspects such as schedules, materials, safety, and energy consumption. However, for this information to be valuable, it must be effectively communicated to the right people and presented in a clear and understandable way (Hasan et al., 2025).

2.3.1 Communication

Effective communication is fundamental to successful project management and is essential for building high-performing project teams (Project Management Institute, 2021). The construction industry is complex, fragmented, and dynamic, involving many different parties, which makes effective communication crucial for managing its challenges. A study by Gamil and Abdul Rahman, 2018 shows that the majority of problems within the industry are caused by poor and ineffective communication. By conducting a literature review 33 different causes of communication issues were identified, with the most significant being a lack of effective communication between the various construction parties. Other important causes include the absence of functional communication systems and platforms, weak communication skills, inappropriate communication channels, as well as differences in education levels, competencies, cultural backgrounds, and language, which often lead to misunderstandings. Additionally, a lack of regular and frequent communication is highlighted as another form of communication deficiency.

According to Obododike Ekwuno, 2022, strong communication enables project managers to better achieve core objectives related to time, cost, and quality. Improved communication among project teams, suppliers, and contractors enhances productivity and reduces the likelihood of failures caused by misunderstandings or coordination issues. It also builds stronger relationships and trust among stakeholders. Effective communication reduces disputes, rework, delays, and cost overruns which are problems commonly linked to poor communication. Technology plays an increasingly important role in supporting communication and collaboration. Project management software and digital platforms provide real-time access to project information and stakeholder engagement opportunities. However, the effectiveness of these technologies depends on their accessibility and appropriate use, as lack of support or improper implementation can exacerbate communication challenges (Obododike Ekwuno, 2022).

According to the PMBOK® Guide 7th Edition, communication methods can be categorized as push, pull, and interactive. Push communication involves one-way messages, such as emails or reports, sent to stakeholders without expecting immediate feedback. This method should be used deliberately, as it limits the ability to assess understanding. Pull communication occurs when stakeholders actively seek out information themselves, for example by accessing templates on an intranet or consulting online repositories. Interactive communication, such as meetings, phone calls, or collaborative sessions, is considered the most engaging, as it enables real-time exchange and understanding. Across all communication types, quick feedback loops are critical to confirm stakeholder comprehension and uncover any unintended interpretations. Furthermore, open communication within teams fosters an environment of trust, collaboration, and shared understanding, key traits of high-performing project teams (Project Management Institute, 2021).

2.4 Cost of Change

In construction the cost of changes increases significantly the later they occur in the project life cycle. Early in the concept and design phases, design decisions can be adjusted with minimal disruption, and these changes often have a high positive impact on the overall outcome of the project. As the project progresses into construction, changes become much more costly due to rework, delays, and material waste. Post-construction changes are the most expensive, often requiring major renovations and disrupting operations (Islam et al., 2019). This pattern is captured in the cost-influence curve in figure 2.1, highlighting the importance of early planning, stakeholder involvement, and tools like BIM to minimize late-stage changes (Project Management Institute, 2021).

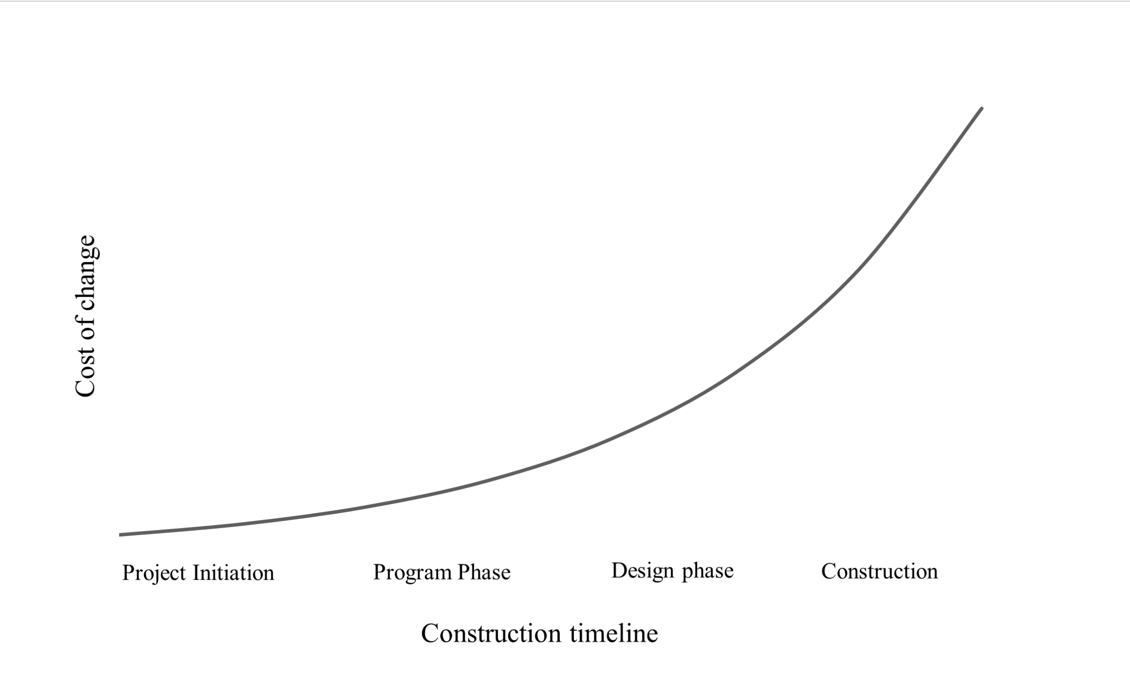

Figure 2.1: Cost of Change Curve

When a building does not preform well rework have to be done during or after the construction phase. This leads to a variance in design of the facilities witch makes the maintenance and repair work more difficult. Many construction defects also appear in the operation face, leading to reparation work, higher operational costs, and disturbance for the users of the buildings The largest contributor to facility management cost was design errors, emerging from incomplete or faulty drawings, details and specifications. Other factors that increase the cost of facility management are also lack of maintenance plan, client requirement and lack of communication and collaboration. (Islam et al., 2019).

2.5 Digital Technology

Technology provides the tools that enable digitalization, but on its own, it does not add value to an organization. Technology in CPM refers to the tools and systems that support project design and construction. CPM technology plays an important role in introducing new and more efficient ways of managing projects, improving processes, and enhancing overall productivity (Marnewick & Marnewick, 2022). Digital solutions in CPM also helps with controlling and monitoring project progress, conducting evaluations, determining design approaches, and driving innovation. These tools, which can include both hardware and software, play a critical role in improving project outcomes. However, their effectiveness depends not only on the tools themselves but also on the skills and expertise of the project team (Walker, 2015).

2.5.1 Digitalization

Digitalization is a large-scale transformation in which technology is widely adopted to improve efficiency and create new opportunities. The socio-technical process refers to the innovation where technology is adopted at a large scale, and digitalization requires a cultural shift within organizations, promoting a digital mindset that values impact, speed, openness, and autonomy (Marnewick & Marnewick, 2022). Digitalization often has a disruptive nature and changes how projects are managed and may reshape the field of project management. However, project management has not yet been fully digitalized and currently relies primarily on technology as a tool rather than as an integrated part of its core processes (Mikhridinova et al., 2023).

2.6 Implementation of Digital Solutions

The construction industry is often seen as slow and conservative in adopting digital solutions. Despite this, innovation continues, and new technologies are emerging within the sector. The development of technology in construction is complex and influenced by various factors. Historically, project owners and builders have played a major role in driving innovation by developing new technologies and integrating different components into functional systems. However, this contrasts with the fact that clients often do not have dedicated R&D departments. Additionally, the project-based nature of the construction industry differs from the product-focused approach of technology inventors, which can create challenges in finding digital solutions that the industry needs (Tangkar & Arditi, 2000). For organizations to fully benefit from digital solutions, it is essential to apply the right tools at the appropriate phase of the project. The project manager plays a key role in selecting and combining digital tools to meet the client's objectives. A successful implementation also requires careful planning, with a focus on integration and adaptation, and the true value of a digital solutions often becomes apparent only after these phases are complete. When utilized effectively, these tools help align project processes with organizational goals and contribute to overall project success (Walker, 2015).

Different stakeholders have varying capacities to implement digital solutions in construction projects. Table 2.1 presents the key stakeholders identified in this report, along with their respective strengths and weaknesses related to the implementation of digital tools.

Table 2.1: Key stakeholders and their ability to effect implementation of digital solutions in the construction industry (Tangkar & Arditi, 2000).

Role	Strength	Weakness
Clients	Provide capital and are primary beneficiaries of successful digital implementation.	Limited experience and knowledge of construction processes can hinder adoption.
Construction Project Managers	Holds industry expertise and knowledge to ensure successful digital adoption.	Dependence on clients can introduce conflicting priorities (Lindahl & Ryd, 2007).
Providers of Digital Solutions	Drive innovation through research and development of new products.	Often lack direct relationships with project owners, complicating implementation.

2.7 Drivers of Digitalization

There is a technology-driven push from inventors and companies with access to R&D, looking to introduce their digital solutions to the market. This push is based on advancements in technology, research, and technical expertise. These technologies are created using technical knowledge, and if necessary, efforts are made to generate user demand, awareness, and interest alongside the new products. This approach is often called "technology-push" (Tangkar & Arditi, 2000).

Market-driven innovation focuses on identifying existing market needs, demands, and opportunities. Instead of starting with the technology, this process begins by understanding what users or the market require, then developing solutions or products to meet those needs. This is known as "market-pull" (Tangkar & Arditi, 2000). Tangkar and Arditi, 2000 highlights that while technology-push is crucial in the invention phase, market-pull plays a bigger role when it comes to the adoption and widespread use of new innovations.

Peoples behavioral change and general attitude towards technology is a driver for digitalization. The more people use digital solutions in their work and life, the more they expect of technology to preform during a construction project. This behavioral change also effect how people communicate with each other during a project

Marnewick and Marnewick, 2022

The construction industry market has been growing for the last decade, but do now have characteristics of a mature market. For example, the growth is slowing down and the competition on the market increases. Mature markets usually have some big players on the market, rather than many smaller companies and when entering a mature market, less profitable companies tend to be excluded from the market and not able to survive past the growth phase. This leads to a reorientation in which companies have to take advantage of available technological advances and have an innovative mindset to gain market shares (Tangkar & Arditi, 2000).

2.7.1 Technology Adoption Life Cycle

The Technology Adoption Life Cycle curve presented in figure 2.2 is a model that explains how people adopt new technologies over time. It helps to understand how technology is used by dividing adopters into different groups based on their willingness to embrace innovation. These groups have different characteristics (Tangkar & Arditi, 2000).

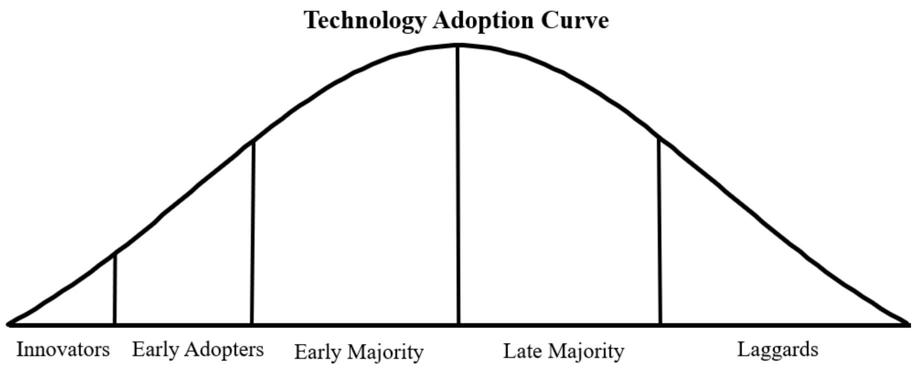

Figure 2.2: Technology Adoption Curve

- Innovators 2.5% – These are the first people to try out a new technology. They are curious, open to risks, and eager to experiment with new ideas before anyone else.
- Early Adopters 13.5% – This group sees the potential of new technology early on and is willing to take risks. They are visionaries who influence others and help drive adoption.
- Early Majority 34% – These individuals are more cautious and practical. They wait until a technology has proven its benefits before adopting it, ensuring it meets their needs.
- Late Majority 34% – This group is more sceptical and prefers to wait until most people have already adopted the technology. They are cautious and dislike taking risks.

- Laggards 16% – These are the last to adopt a new technology. They are resistant to change and only start using it when it has become standard and widely accepted.

2.8 Challenges for Implementation of Digital Solutions

Today, project management cannot be called a highly digitalized process, however there are digital solutions used today to help project management in their work. The challenges with implementing digital solutions can be either technical or people orientated (Tangkar & Arditi, 2000).

2.8.1 Cost

One challenge of digitalization is the cost of implementation. Companies are often hesitant to invest in digital solutions without confidence in a positive return on investment. Beyond the expense of new software or technologies, implementation also involves hidden costs such as personnel training and ongoing maintenance. The cost associated with digital solutions makes companies' reluctant, especially when striving for strong financial performances. The unclear benefits of digitalization in the construction industry in general pose a challenge to its implementation. Both construction companies and clients often struggle to see the value of digital transformation, making them resistant to changing established working practices. Additionally, the industry's fragmented nature further hinders the adoption of digital solutions. With frequently changing teams and project-based work structures, ensuring long-term and consistent digital adoption becomes increasingly difficult. (Demirkesen & Tezel, 2021)

2.8.2 Data Security

The construction industry has traditionally not focused much on safeguarding digital information. However, as digital tools become an increasingly important part of project management, the need for strong data protection is increasing (Demirkesen & Tezel, 2021). CDEs and other cloud-based systems increase the vulnerability to cyber threats due to the concentration of sensitive data stored in a single location (Parn & Edwards, 2019). These risks include the unauthorized access to confidential files, deletion or tampering with digital records, and the theft of personal or company information. To reduce these risks, stakeholders in the construction industry should improve their digital systems and carefully check for cybersecurity problems. This includes investing in secure platforms, ensuring proper access controls, and create a culture of cybersecurity awareness throughout the organization (Demirkesen & Tezel, 2021). Expanding existing standards, such as ISO and BIM-related protocols, and promote cybersecurity awareness in publicly funded BIM projects are also important steps to help prepare the construction industry (Brelih & Klinc, 2025). New technologies like blockchain offer useful ways to improve data security. Blockchain allows sensitive project information to be stored and shared in a secure way that cannot be changed and does not rely on a central system (Parn & Edwards, 2019).

Another important dimension of data security is the physical protection of the data servers. Server providers are responsible for maintaining and securing the physical infrastructure that hosts construction project data. These servers are exposed to physical and cyber threats, which makes their geographical location and access to stable power supply critical factors for ensuring operational security (Brelih & Klinc, 2025).

2.9 Digital Solutions

There are many digital solutions that have been developed and adapted for use in the construction industry. Building Information Model (BIM), Virtual Reality (VR), Augmented Reality (AR), Digital Twins (DT), and Artificial Intelligence (AI) are examples of technologies that are increasingly being explored within the sector. These solutions have the potential to influence various aspects of construction processes, including planning, design, execution, and operation.

2.9.1 Building Information Model

The Building Information Modeling refers to the process of creating and managing information for a built asset with a digital model available on a cloud based platform. Typically, Building Information Model (BIM) models are three-dimensional representations of building components, but they also include non-physical elements such as zones, schedules, and system interactions. Each object within the model is defined by semantic information that describes its properties, type, and relationships to other components (Borrmann et al., 2018). BIM is useful for identifying potential issues early, enhancing design coordination, construction control, and project handovers. By minimizing manual data entry and enabling the seamless exchange of information, it reduces errors and increases productivity and quality in construction projects. BIM models are applicable throughout the entire life cycle of an asset, from planning and construction to maintenance and operation. Although previous research has focused on the usage of BIM during the design phase, where its benefits are widely acknowledged, implementation during the construction phase has been more limited (Disney et al., 2024).

In Sweden, the construction industry has increasingly embraced model-based working practices, with a relatively high adoption of BIM. However, the perception of what BIM adoption entails varies between individuals and organizations, and while some only interpret it as working with BIM models, others have a more holistic perspective including working processes and information management (Borrmann et al., 2018).

2.9.2 Total BIM

Recently, the concept of "Total BIM" has emerged, aiming for fully digital projects without the need for paper-based documents or 2D drawings (Disney et al., 2024). Total BIM is understood as embracing BIM in its totality where the BIM model is the single source of information in all project phases. The digital model serves as both a legally and contractually binding document, and all data is accessed via cloud services. Traditionally, if BIM is used in the design phase, designers decide which section drawings to produce, sometimes choosing the easiest ones to represent. With Total BIM, site workers can generate the specific construction details they need, making the information more practical for on-site use. Rather than being a digital version of 2D drawings, with Total BIM workers can create the views and sections they require. However, the Total BIM approach places demands on designers to prepare the model for construction so that it can serve as the sole source of information during the construction phase. It also requires constant updates to the BIM model, otherwise it will not be trusted and used on the construction site. (Disney et al., 2023).

2.9.3 Virtual Reality and Augmented Reality

Virtual reality (VR) allows users to experience digital environments as if they were real, providing a sense of scale and detailed visualization. This immersive technology enables users to explore and inspect virtual environments in a highly realistic way, significantly enhancing comprehension and spatial understanding. When combined with BIM, VR becomes a tool for, among other things, construction safety planning, construction scheduling, and the creation of virtual showrooms (Johansson & Roupé, 2024). VR is also a valuable tool for safety training, offering a risk-free environment where users can practice identifying and managing potential hazards (Hasan et al., 2025).

Augmented reality (AR) does not immerse the user in a fully virtual environment but instead overlays digital information onto the real world. AR stands out for its accessibility, as mobile devices and similar technologies makes it available to users at all time. In construction, AR can be a useful tool for visualizing clash detection between planned installations and existing structures. It also supports construction workers by facilitating progress checks and evaluating retrofit work (Hasan et al., 2025).

2.9.4 Digital Twin

A digital twin (DT) is a software model that represent the behavior of a real-world object. By running simulations within the DT, users can understand how the physical object would react under specific conditions (Crespi et al., 2023). The complexity of digital twins varies, determining how accurately they replicate reality. To maintain this accuracy, real-time data must be fed into the software model. DT can process both real-time and historical data and with the support of AI and machine learning, this enables predictive services, scenario planning, and more informed decision-making throughout the asset's life cycle. Construction companies can use digital twins to track past, current, and future performance, optimizing design, maintenance, and operations while identifying and solving potential problems before they occur (Crespi et al., 2023).

2.9.5 Artificial Intelligence

Artificial intelligence (AI) refers to a collection of methods and technologies that allow computers to behave similar to human thinking by analyzing data and learn from experience. AI can be used in project management to improve performance productivity by taking over routine tasks. Many project leaders believe that AI will help making project work more efficient and improve the quality of results. By using AI teams can get useful insights and suggestions to support better decisions, make better use of resources, and plan projects more effectively (Taboada et al., 2023).

AI can understand instructions given in everyday language and turn them into actions that can be carried out. This means it can help automate tasks like scheduling, setting reminders, and managing calendars, making sure the project stays on time. AI can also improve communication and teamwork by being built into project management tools. For example, AI chatbots can help team members share information, ask questions, and stay updated, which makes it easier to stay organized (Shoushtari et al., 2024). By looking at project data, AI can also help find possible risks early and suggest ways to reduce or avoid them. When combined with BIM, it can also be used to check and manage the quality of construction work. This helps make sure that standards are followed and lowers the risk of mistakes or defects. (Nie, 2024).

2.10 Common Data Environment

A Common Data Environment (CDE) is a shared digital platform used in construction projects to enhance collaboration across different disciplines. It allows project members to upload, access, and manage models and documents in a centralized location. By supporting a continuous flow of information and regular file updates, CDEs facilitate real-time collaboration and coordination. This streamlined exchange of data has led the industry to regard CDEs as a standard solution for improving communication and teamwork within projects (Lindholm et al., 2025).

A CDE is defined by six essential features that ensure efficient collaboration and information management in construction projects. These are filtering, workflows, communication, version management, rights administration, and status management. Filtering helps users navigate large volumes of data by enabling quick access to relevant information, allowing issues and queries to be addressed efficiently. Workflows ensure that all communication and data exchange occur within the CDE, guided by structured protocols and metadata-driven status codes, reducing the need for emails or printed documents. Communication features support collaboration by enabling task assignments and facilitating information exchange through comments and requests for information. Version management tracks changes by archiving previous versions and maintaining access to the most current one, which helps prevent confusion and supports legal traceability. Rights administration regulates access based on user roles, ensuring that participants have appropriate permissions to view, edit, or delete content. Finally, status management oversees the progression of documents through revisions and approvals, ensuring that the final version is properly published and archived, often integrated into an asset information model (Dolla et al., 2024).

2.10.1 Dalux

Dalux is a CDE software that enables users to access information from the BIM model. It offers tools for all phases of a construction project, from design and construction to maintenance and property management. Key features that can be utilized by construction project managers include the 3D model, issue tracking, document management, and tools for quality inspections and safety rounds. Dalux open API allows users to connect data with customize features adapted for their needs (Dalux, n.d.).

The 3D module in Dalux enables users to navigate in the project's digital model, create cross-sections and make crash controls within the model. The Dalux BIM viewer also allows for comparisons between the physical construction site, 2D drawings and the digital 3D model, making it easier to track project progress and ensure accuracy throughout the building process (Dalux, n.d.). Dalux is user-friendly, particularly when it comes to interpreting visual information in the 3D model, which has contributed to its widespread adoption in the industry. The different discipline models, such as architectural, ventilation, and piping, form the foundation of the information, and in the 3D model, users can select an interface that displays one or multiple models simultaneously (Sjöstedt, 2025).

The RFI (Requests For Information) function in Dalux is a core module for handling technical and administrative questions in a structured and traceable way. It facilitates communication between stakeholders such as clients, designers, construction project managers, and contractors, ensuring that decisions are not lost in emails or verbal exchanges (Alsnäs, 2025). Users can assign questions to responsible parties, involve additional disciplines as needed, and track the progress through status indicators like ongoing, completed, or key issue. Each issue can be linked to a specific location in the BIM model and documented with images, text, and product information, creating a clear record of how it was resolved. (Oshalim, 2025).

2.10.2 StreamBIM

StreamBIM is a cloud-based collaboration platform built on BIM and designed for the AEC industry to ensure real-time information flow between stakeholders throughout all phases of a construction project. The platform offers tools for issue and task management, measurement, inspections, punch lists, coordination, and construction planning, making it easy for all project members to collaborate (StreamBIM, n.d.-a).

StreamBIM allows users to visualize assets and specific objects in both 2D and 3D views. Its features provide access to BIM models from devices, including computers, smartphones, and tablets and enabling users to create custom cross-sections and perform real-time measurements. StreamBIM supports real-time communication by allowing users to create and respond to RFIs and link checklists, photos, and issues to specific model elements. Push notifications ensure that tasks and updates are not missed, enhancing collaboration across disciplines (Disney et al., 2023).

One of the key advantages of StreamBIM is its ability to link data to individual objects. All relevant information structures associated with the objects are made accessible at the object level (Sjöstedt, 2025). This allows for filtering and quantity takeoff based on specific objects within the model (Disney et al., 2023) Although objects are placed within the model, they also reside in defined spaces and are part of larger zones containing multiple spaces. As a result, it is possible to filter object information structures at the level of an entire floor (Sjöstedt, 2025).

StreamBIM's QR code functionality enhances on-site efficiency by linking physical elements directly to the digital model. Each QR code is unique to a specific object, location, or component within the project. When scanned, it provides access to object-specific information and documentation, such as drawings, installation instructions, maintenance guidelines, or inspection records (StreamBIM, n.d.-a).

StreamBIM's TAKT module enables lean-inspired, model-based construction planning and real-time progress monitoring within the BIM environment. This approach helps streamline construction workflows by structuring construction into repeatable, synchronized work sequences, improving coordination between teams and minimizing delays. Construction is then divided into work packages that are linked to specific zones in the BIM model. These packages are arranged in sequences, supported by checklists and responsibilities, that move through the building or site at regular intervals. (StreamBIM, n.d.-b).

StreamBIM addresses the challenges of data security by offering solutions tailored to meet varying levels of data protection, including on-prem offline solution, regional server options, and ISO 27001 certification. One of StreamBIM's key offerings is its Swedish server solution, designed specifically for construction projects based in Sweden. This solution allows users to store project data within Swedish borders, ensuring compliance with local regulations, enhanced privacy, and high performance. StreamBIM also offers the option to stream data from the cloud to users' devices, eliminating the need for in-house servers (StreamBIM, n.d.-c). StreamBIM also supports open standards such as IFC, making it possible for third-party users to integrate and collaborate within the platform. With its open API it integrates functions for issue tracking, scheduling, and data visualization tools such as Power BI, making it suitable for use throughout the entire construction and quality management process (Monsen et al., 2022).

2.10.3 Autodesk Construction Cloud

Autodesk Construction Cloud (ACC) is a cloud-based construction management platform developed by Autodesk that has tools and workflows for the entire building life cycle. It includes many modules. Autodesk Docs is used for document management. Autodesk BIM Collaborate for model coordination and clash detection. Autodesk Build for field collaboration and project tracking. Autodesk Takeoff for generating quantity estimates from 2D and 3D designs (Autodesk, n.d.-a). Additionally, ACC offers data analytics through Autodesk Insight and supports financial tracking and change management via Autodesk Cost. Autodesk Cost includes budget creation and administration, change orders, payment applications and also cost forecasting (Autodesk, n.d.-b). RFI:s, field observations and deviations can be documented with photos that are tagged to relevant person or group and linked to the BIM model. Reports can then be exported for use in quality assurance or for communication with clients (Autodesk, n.d.-a).

One of the main selling points of ACC is that it operates with live data stored in the cloud, eliminating the need for IFC files (Sjöstedt, 2025). Since most projects are created in Revit, and both Revit and ACC are owned by Autodesk, the platform can access and integrate project data in real time (Kärkkäinen & Yledahl, 2025).

ACC is accessible both as a mobile app and in a web browser, since all project data is stored in the cloud. Files can also be downloaded for offline use, ensuring access without an internet connection (Kärkkäinen & Yledahl, 2025). ACCs BIM viewer has a BETA version where it is possible to take measurements directly in the mobile or tablet app by tapping on two points (Autodesk, n.d.-c).

ACC also offers several APIs, allowing developers to create apps that integrate with the Autodesk software (Autodesk, 2025). One function suited for the construction phase is Assets. Assets allows detailed information to be linked to each building object as part of a larger system. Users can specify required life cycle stages, such as inspection or testing, and attach documentation, serial numbers, or even require photographic evidence before the asset progresses to the next stage. Each asset can be linked directly to the BIM model, enabling teams to visualize its exact position and status in real time. This can future build up to a time plan covering for the whole project (Sjöstedt, 2025). It is possible to filter on object status, location or other costumed fields. The information transfers to operations, where the facility manager can import the information into their system without manual input or missing details (Kärkkäinen & Yledahl, 2025).

The next level of using Assets is integrating it with other functions via APIs. This allows assets to be connected to, for example, ISO standards, making it possible to track whether required data points are delivered according to those standards.

Assets can also link construction to the project's schedule and budget, making it possible to identify the effect of delays or deviations immediately. This enhancing control and traceability. Using QR codes, workers on site can scan an object to access relevant drawings, current construction phase, and technical specifications, ensuring the right information is available at the right time. Progress can be easily documented through photos or by scanning serial numbers, making it simple to verify and log when each step is completed (Sjöstedt, 2025).

An update from BIM 360, is the Bridge feature. This functionality facilitates the controlled sharing of information between different projects without requiring all stakeholders to operate within the same project environment or data hub (Autodesk, n.d.-a) . With Autodesk Bridge, project participants maintain ownership of their own data while selectively sharing specific models, documents, or updates with other projects through a link. This helps cross-project collaboration and data management, especially in large organizations or between different contractors and consultants involved in multiple projects (Kärkkäinen & Yledahl, 2025).

2.11 Digitalization and Reuse

Reuse in the AEC industry refers to the practice of taking building components or materials from one project and use them again in another, without major reprocessing. It plays a vital role in the waste hierarchy and reuse helps reduce the need for new raw materials, lowers carbon emissions, and limits the volume of construction and demolition waste sent to landfills (Knoth et al., 2022). Research from the Nordic region shows that reuse in construction can cut resource use by up to 20%, and lead to substantial reductions in greenhouse gas emissions. In Sweden a cut down by 20% would lead to approximately 3 400 000 tons CO2 equivalents being saved annually (Høibye & Sand, 2018).

BIM has strong potential to support disassembly and reuse by offering a digital representation of building components with the information needed for selective disassembly. It can help identify reusable parts before demolition, simplify planning, and reduce waste by making it easier to recover components in good condition. To support this, BIM models can be enriched with semantic data, such as material types, connection methods, and reuse potential. When structured and updated correctly, BIM enables a more circular approach to construction, where components are treated as long-term assets rather than waste. However, recent studies show that many current BIM models still lack the detailed data needed for disassembly planning. A common issue is that as-built models are outdated, incomplete, or missing, making it harder to understand how to reuse materials from a building. As a result, disassembly often depends on manual inspections, which are time-consuming and less efficient (Sanchez et al., 2021).

3 Methods

This chapter presents the research methodology used in the study. A combination of a literature review and an interview study was used to identify both the current status and future opportunities and challenges associated with digitalization in the construction industry.

3.1 Research Strategy

A qualitative research strategy is chosen for this master's thesis. According to Bell and Waters, 2014 a qualitative research strategy typically involves the use of non-numerical, unstructured data and often begins with a broad research question. Qualitative research is particularly effective when the aim is to explore individuals' perceptions, experiences, and attitudes. By making use of this method, it is possible to explore how digital tools are used during the construction phase of construction projects and what the future opportunities are for clients and construction project managers. An important feature of qualitative research is its flexibility. The research process can be adapted as new insights emerge, and interview questions can be refined based on preliminary findings. This supports a deeper exploration of the research topic and ensures that the study remains responsive to the data.

Based on Bell and Waters, 2014 guidance, data of this character is best fitted to be collected through semi-structured interviews, allowing for open-ended responses. The data from the interviews was analyzed using thematic analysis to identify key themes and insights (Braun & Clarke, 2023). These combined strategies aim to supports a better understanding of the interview data.

3.2 Time Frame

The study was conducted between January and June 2025. The work begun with a literature study. Once the problem formulation and research questions were developed, based on findings from the literature, the theoretical framework was initiated.

Although the theoretical framework was refined throughout the entire research process, most of the work in this area took place during the first month of the project. Preparations for the interview study began in mid-February, and the first interview was conducted on February 27. Interviews were carried out over a two-month period.

A significant portion of time was devoted to transcribing and analyzing the interview data. This process was ongoing and conducted in parallel with the interviews. Following the completion of the interviews, the results were compiled. These findings then formed the basis for the analysis and discussion chapters, which were developed using insights from both the empirical material and the theoretical framework. Finally, the conclusions were summarized in the concluding chapter and the report was reviewed.

3.3 Literature Study and Theoretical Framework

The literature study was conducted to establish a theoretical foundation for the thesis and to provide context for the research questions. Its purpose was to examine the current state of digitalization in the construction industry, with a particular focus on the construction phase. The review aimed to identify key trends, commonly used digital tools, barriers to broader implementation, and how digitalization can create value for clients.

The literature study focused on three main areas, the adoption of digital tools in the construction industry, challenges and barriers to digital implementation, and the connection between digital solutions and client value. These areas were selected to align with the aim of the thesis. The study began with a broad search for academic articles, reports, and industry publications. Keywords and search strings were formulated to target both general and specific aspects of digitalization in construction. Examples of search terms used include:

- “Construction management” AND Digitalization OR Digitalization OR “Digital solutions” or “Digital tools”
- Digitalization AND "Construction" AND "Client value"
- "Construction" AND "Client value"
- "Construction management" AND "Client satisfaction" OR "Stakeholder engagement"
- "Data security" OR "IT security" AND AEC industry
- "BIM" AND "client value" AND "construction "
- "Digital twins" AND "client value" AND "construction "
- "AI" AND "construction" AND "project management"

The primary search engines used were Google Scholar and the Chalmers Library portal. Given the rapid development of digital tools in recent years, the time scope of the literature was limited to publications from 2015 onwards. These search strings generated a large number of articles and the material was evaluated based on abstract reading. The credibility, and relevance to the construction context in Sweden and Northern Europe was evaluated and articles not meeting the demands were excluded.

To complement the academic literature, information about the CDEs, Dalux, Autodesk Construction Cloud (ACC), and StreamBIM, was gathered from official company websites and available learning resources. This provided an overview of the platforms' key features and intended use in construction projects. This material was used for understanding how the tools function in practice and supported the analysis of their perceived usefulness in the empirical part of the study.

The literature review was conducted in parallel with the interview study. As new topics and perspectives emerged from the interviews, additional literature was sought to support or contrast the empirical findings. This iterative approach strengthened the connection between theory and practice and ensured that the literature study remained relevant throughout the research process.

3.4 Interview Study

To investigate the current use of digital solutions in the construction phase of construction projects, a qualitative interview study was conducted. The aim was to explore how digital tools are perceived and utilized by different stakeholders in the AEC industry and to identify both opportunities and challenges associated with their implementation.

Semi-structured interviews were selected to provide both consistency and flexibility. The interview participants were divided into the three main groups, construction project managers, experts and clients. Three interview guides were developed in advance (see Appendix A, B, C), adapted for the three main categories of participants. The interview guide contains open-ended questions focused on the usability, perceived value, and limitations of digital tools in the construction phase. All participants were asked to limit their responses to the construction phase, to maintain a clear focus on the implementation and use of tools for CPM. All interviews, expect the one with Expert 3 were conducted in Swedish since that was the preferred language of all participants.

A list of all interviewees is presented in Table 3.1 together with a short description of their role. The number of participants is considered appropriate for the scope of a master's thesis and aligns with recommendations for conducting thematic analysis in qualitative research. Each interview lasted approximately one hour and was held either in person or via Microsoft Teams, depending on availability and location. All interviews except one were conducted in Swedish and later translated into English. The interviewees received information on the purpose of the study prior to the interview and were encouraged to share their perspectives based on both their current roles and any relevant previous experience in the AEC sector.

Table 3.1: List of interviewed candidates and their role. a and b represents two interviewees present at the same interview.

Interviewee	Role	Date
Construction Project Manager 1	Construction Project Manager	2025-02-27
Construction Project Manager 2	Construction Project Manager	2025-03-04
Construction Project Manager 3	Construction Project Manager	2025-03-07
Construction Project Manager 4	Construction Project Manager	2025-03-18
Expert 1	BIM Coordinator & BIM Strategist	2025-02-17
Expert 2a	Site Manager at a fully digital CM company	2025-03-03
Expert 2b	Project Manager and Digital Lead at a fully digital CM company	2025-03-03
Expert 3	Researcher in Digitalization in the Construction Industry, at Chalmers Tekniska Högskola	2025-04-28
Expert 4a	Technical Solution Executive at Autodesk	2025-03-31
Expert 4b	Data Platform Specialist at Autodesk	2025-03-31
Expert 5	Customer Success Manager at Dalux	2025-04-13
Client 1	Project Manager at Client Organization	2025-03-11
Client 2	Project Manager at Client Organization	2025-04-07
Client 3a	Project Manager at Client Organization	2025-04-08
Client 3b	Project Manager at Client Organization	2025-04-08
Client 4	Project Manager at Client Organization	2025-04-08

Explanation of the context the client organization work in:

Client 1 - A private client managing a diverse portfolio of complex facilities, actively engaged in facility management.

Client 2 - A state-owned company that initiate, develop and produce dwellings. Focus is to lower the construction cost and carbon footprint.

Client 3 - A private company that own, develop and manage logistic real estate in Europe.

Client 4 - A state-owned organization who own, develop and manage dwellings and complex facilities.

3.4.1 Additional Sources

In addition to the primary interview study, supplementary material was reviewed from a recorded presentation of a state-of-the-art construction project in Norway. This large-scale hospital construction project in Norway, is recognized for its advanced use of digital tools and methods, and the successful project outcome. The video recording featured three project managers who discussed the use of digital solutions in scheduling, systematic completion, and communication, see table 3.2. The material was included in the results, especially in the result covering StreamBIM´s usability.

Table 3.2: List of people presenting in the video recording and their roles in the project.

Interviewee	Role	Date
Expert 6a	Project Manager Systematic Completion	2022-06-20
Expert 6b	Project Manager from Client Organization	2022-06-20
Expert 6c	Project Manager Scheduling, VDC, Lean Construction	2022-06-20

Informal discussions with professionals outside the recorded interviews also contributed to the authors' understanding of the topic. These inputs were not used as formal data, but they sparked ideas and reflections that are considered in the discussion chapter.

3.4.2 Data Processing

The video recordings from the interviews were transcribed and the material was anonymized, with all personal names and organizational affiliations replaced. Given the semi-structured format of the interviews and the use of different set of questions for the three groups, the content varied both in focus and detail. To ensure consistency in the analysis, all responses were organized according to key themes aligned with the research questions and highlighted as key topics by the interviewees. The themes included communication, digital tools, CDEs, and BIM models, with a focus on client value, the utility of construction project management, and perceived hinders and challenges. A cross-comparison of the responses was made. A thematic analysis was afterwards conducted to identify recurring patterns, similarities, and differences among the candidates. Key quotations were selected and translated into English to illustrate the core findings and to support the conclusions presented in the results and discussion chapters.

3.5 Limitations of the Method

While the open interview format allowed for discussions and multiple perspectives, it also resulted in highly varied responses which made direct comparisons more challenging. Additionally, as this is a qualitative study, we were unable to validate individual statements with larger datasets, which limits the statistical strength of the findings. The research could have been enhanced by a quantitative component, such as a survey exploring users' perceived value or experience with digital tools, to support and validate the qualitative findings.

The lack of direct interviews with experts on StreamBIM can also be considered a limitation. Although we conducted interviews with ACC and Dalux experts, our understanding of StreamBIM was based solely on recorded materials. This limited our ability to ask follow-up questions. Ideally, the study would have included interviews with experts from all three platforms to ensure a more balanced and in-depth comparison.

The client organizations involved in the study were relatively few. Since clients differ in structure and digital maturity, their ability to derive value from digital tools can vary. Including a more diverse range of clients would likely have provided a broader and more representative view.

Bell also highlights the case study approach as a valuable design within qualitative research. When a study focuses on a specific project, organization, or professional role, the case study method enables an in-depth and contextual analysis. For a thesis that involves interviews with construction project managers and other construction stakeholders, this approach could have gathered richer, more detailed insights that may not emerge through quantitative methods.

3.6 Ethical Aspects

Ethical considerations were taken into account in both the design and implementation of the study. All interviewees were informed in advance about the purpose of the research, how their responses would be used, and their right to anonymity. Consent was obtained verbally prior to recording the interviews. All participants were anonymized in the results, and no names or personal identifiers are included in the thesis. Organizations have also been anonymized unless they represent a company that provides a CDE featured in the study, namely Dalux and Autodesk. Interviews were recorded either through the audio recording function in Teams or via an external audio device. The recordings were used solely for transcription purposes and were deleted after transcription and anonymization. The transcripts were only used by the authors of this thesis.

The study does not present any results that could be directly harmful to individuals or professional roles. Nevertheless, it touches on issues related to implementation challenges, organizational readiness, and digital competence, which are discussed with care to avoid unjust generalizations.

3.6.1 Use of AI

AI was used as a support tool to improve language quality, and to facilitate data handling. AI technologies were not used to produce original analytical content or generate research findings. One of the main applications of AI in this study was automatic transcription of interview recordings. Interviews conducted in Swedish were transcribed using the Chalmers AI Portal. After transcription, all material was reviewed and edited for accuracy, with special attention to correct terminology and context.

AI was also used for translation purposes. Since the majority of interviews were conducted in Swedish, the quotations were translated into English using AI-supported translation tools. As with the transcriptions, all translations were manually reviewed and revised to ensure they captured the intended meaning and preserved the nuance of the original statements.

Another area where AI contributed was in language editing. AI-based writing assistants were used to check grammar and sentence structure. These tools provided suggestions for improving clarity and academic tone, but the final decisions on wording, structure, and content were made by the authors.

4
Result

This chapter presents the results based on the interview study and recorded presentations, organized into sections based on the main discussion points from the interviews. The topics include communication, time plans, BIM models, facility management, digital tools, CDEs, and contract structures.

4.1 Communication

The study shows that communication is a crucial factor in construction project management, where multiple stakeholders need to collaborate and remain updated on time plans and arising questions throughout the project's life cycle. Construction project managers describe how much of the communication still relies on traditional channels such as email, phone calls, and site visits. Construction Project Managers 2 and 3 note that critical decisions sometimes get stuck in personal email threads, creating a risk of information loss. The experts agree that traditional communication is inefficient since only the person who receives the email gets the information.

Construction Project Manager 2 explains that certain information, particularly photos from site visits, is stored locally on personal computers and not shared with other stakeholders. This results in information silos, where important knowledge remains personal and is not passed on to the client. For the client, this creates issues of oversight and control. Client 1 describes how she uses Dalux to collect project documentation, drawings, and communication through the RFS module. For her, the value of Dalux lies in the traceability, structure, and ability to export the communication into final documentation:

"If Dalux isn't used, the issues are all over the place in the inbox, and then you have to keep track of your inbox and maintain a manual decision log. I've chosen to keep it in Dalux because then it's clear what the sub-questions are, how the issue has developed, and what the final decision was."

Several clients emphasize the importance of centralizing project documentation and queries in a single location. Client 3a, who has not progressed as far in the digitalization process, believes there would be significant value in having all relevant information collected in one place:

"It would be nice if as few questions as possible came directly to me, and the ones that

did were gathered in one place where you can make decisions, answer the question, and have the necessary background information. Basically, have the information collected so you can go back to it later if needed."

Client 4 notes that the most difficult aspect of managing information and communication in construction projects is ensuring that everyone is talking about the same thing. She uses Dalux to distribute the correct information by pointing to what she means in the model.

According to the experts, digital tools can simplify communication by creating a centralized, structured, and traceable flow of information. Issues, meeting minutes, self-inspections, and deviations can be registered and followed up directly within CDEs such as Dalux, StreamBIM, or ACC. According to Expert 1, one major issue is that clients often have to make decisions based on incomplete information, and the information they receive is often filtered through what others choose to show them. Expert 2 adds that with CDE:s, clients can actively follow the project more closely during both the design and construction phases.

4.1.1 Site Meetings and Site Visits

During the interviews, site meetings have been mentioned as a central platform for decision-making and follow-up during the construction phase. These meetings are typically held every two to three weeks and bring together construction project managers, clients, and contractors. Decisions are documented in meeting minutes. However, several interviewees highlight weaknesses in both structure and consistency. Construction project manager 3 describes the challenge of taking notes during active discussions, which can lead to important information being lost. He explains:

"Sometimes it moves very fast. Sometimes you're writing, and at the same time a discussion is taking place around the table, and then it's not always easy to keep up."

Several construction project managers also emphasize the risk that contractors who do not attend the meetings miss out on the information that is distributed afterward. Construction Project Manager 3 notes that even though the minutes are emailed after the meeting, it is common for contractors not to read them.

Expert 1 specifically highlights the issue of prolonged latency periods. Latency refers to the time between when a question arises and when it is answered. With site meetings held every other week, Expert 1 describes how valuable time is lost, and several weeks may pass before a response is provided.

However, several construction project managers explain that important decisions are often made on-site or communicated via email and phone between meetings. In such cases, the site meeting minutes serve as a log to record decisions made outside the formal meeting structure. Some managers use "Questions & Answers" documents in Word or Excel to track issues between meetings, marking questions as resolved to increase clarity. Still, Construction Project Manager 2 points out that some decisions remain buried in email threads between meetings, which allows contractors to claim they never received the information. Construction Project Manager 4 emphasizes that decisions made via email are not always transferred into the official meeting record.

CDEs such as StreamBIM and Dalux are used to consolidate decision-making documentation. Client 1, who uses Dalux in their projects, explains how the CDE is utilized to answer questions between site meetings and to document decisions. During meetings, Dalux serves as a tool for collecting unresolved issues.

Site visits are a means for construction project managers to monitor progress, quality, and safety on the construction site. Currently, construction project managers describe how site visits often involve using a mobile phone or iPad taking photos of any deviations and noting observations. After the visit, they compile Word documents, relying on memory to add explanatory text and describe the location of each issue. These documents are then shared with the relevant parties. However, this approach can lead to misunderstandings and often results in considerable time spent locating the exact spot. Expert 1 emphasizes that traditional site visits often do not provide a comprehensive overview and that much time is spent on manual tasks. Instead experts describe how photos can be directly uploaded into CDEs, where they can be tagged to a specific location or part of the building model. This allows for precise follow-up on what has been documented, where it occurred, and at which stage. This functionality not only provides clarity for the construction project manager but also for the client, who can use the information as a basis for decision-making or warranty-related matters.

Expert 3 describes how CDEs are used in more advanced projects to manage all communication, including safety rounds, change orders, and construction-related queries, directly linked to the model. By assigning each contract a separate category and linking issues to objects and geographical points in the model, questions can be managed much faster and more clearly.

4.2 Time Plan

Several construction project managers describe how they manage and follow up the time plan during site meetings. In many projects, the contractor is responsible for the construction time plan, and the construction project manager's monitoring is often limited to dialogue with the contractor and inspections of the construction site. Construction Project Manager 2 explains that he often only has access to a PDF version of the schedule, and that follow-up usually involves asking the contractor how things are progressing:

"When the contractor says they're on track, it's difficult as the client representative to know whether that's actually true."

Construction Project Manager 3 mentions that in some cases, paper copies are used, where both the construction project manager and the contractor manually draw progress directly onto the document. This can result in various activities being represented by a single line, making the tracking process imprecise.

In contrast, Expert 2 demonstrate a more digitally integrated approach. StreamBIM and PowerBI enable real-time visual tracking of the status of each activity, with color-coded installation zones linked to their construction status. Expert 2 describes how reports are generated directly from StreamBIM for use in site meetings:

"We generate reports on how they [the contractors] are doing. We look at construction remarks, inspection remarks, safety walk remarks. So we generate a lot of reports and send them to the site meetings."

According to Expert 6a, the client organization in their project implemented a system called *Systematic completion* to enable more structured monitoring of construction progress with the use of object specific status codes. The drivers for implementing systematic completion on an object level, is for the construction management team to be able to track the construction progress on an object level. The use of status codes allowed real-time tracking of each installation to show whether it had been installed, connected, self-inspected, or function-tested, along with other custom status parameters. According to Expert 6a, the greatest benefit of systematic completion lies in identifying what has not yet been completed.

A similar level of structured life cycle tracking is also enabled in ACC through its Assets module. This process enables clear delivery criteria, verified in the field through QR codes linked to each physical asset or installation zone. Expert 4b explains:

"When they scan the QR code, the exact part of the system appears along with the necessary drawings. It will indicate which stage they're in, so if it is the installation phase, it will tell them: you are in the installation stage, you need these components to do the work. Here are the drawings. Here are the technical specifications you need to complete your task. That way, they can do it on site with the right information at the right time."

The Asset module can also be connected to project timeplans and budgets. Expert 4b gives an example of how a damaged delivery that delays installation can be flagged directly in the timeline and budget:

"When something was received and the package was damaged, they could highlight it immediately, and it would appear on the schedule. [...] And when it's highlighted in the schedule, it's also highlighted in the budget, and then you can see what extra costs you will get."

4.3 BIM models

Experts explained that BIM models created during the design phase are exported using IFC files, which are then imported into CDE:s used at the construction site. CDEs allow users to cut through sections in the model, isolate specific installations, and examine details in a 3D view. The BIM model appears as a key tool for enhancing understanding, quality, and coordination in construction projects, not only for designers and construction project managers, but also for clients and the facility management team. Compared to 2D drawings, where different installations not can be seen in relation to each other, BIM models enables a clearer understanding of spatial relationships, such as the interplay between ventilation, electrical systems, and piping. Several interviewees emphasized the model's strength in visualizing both the project's design and the combined technical systems in three dimensions, helping to create a shared understanding. This makes it easier to detect potential problem areas before they arise during construction . As Client 1 expressed it:

"Everyone works in 3D today, and this is incredibly valuable, not only for me as a project manager, but also for construction project managers, designers, and operational staff to understand how things will actually turn out. It's an excellent tool for building understanding."

For construction project managers, the BIM model serves as a tool for review and quality assurance of what is to be built. It also becomes clear that construction project managers use the model to anticipate problem areas, which benefits both the client and overall project efficiency. Several construction project managers emphasize that identifying problem areas and clashes between installations is significantly easier in 3D compared to working with separate 2D drawings. Even if identifying problems with the model is not a primary task for a construction project manager, avoiding potential issues early on is seen as a win for everyone involved in the project. As Construction Project Manager 1 put it:

"Reviewing the 3D model becomes a tool where I can contribute. I draw on my own experience of issues I've encountered in the past. I can go into the 3D model and identify areas we need to watch out for."

There are challenges with implementing BIM models and CDEs in construction project management. Expert 1 describes how it is still common for many projects to use drawings as the primary source of information. Expert 2 continues, drawing on experience from their own projects where they have demonstrated to the facility management the potential of using BIM models:

"Some people find it burdensome to learn something new. They just want to keep doing things the way they always have."

4.3.1 Correctly Designed Models

Expert 2 highlights that, for them, the greatest advantage of using BIM models during construction lies in the quality of the designed models. Fewer drawing errors, better coordination, and the ability to conduct clash detections result in a more reliable design basis. They explain:

"The biggest benefit of using the 3D model during construction is that the project has been designed in 3D. When we design digitally, we make fewer mistakes, which means fewer construction errors. This makes it easier to deliver on time and stay within budget. Most delays during construction occur when the design work is incomplete."

Working with BIM models in construction requires higher initial design costs, but experience from Expert 2 has shown that the total project cost is recovered during the construction phase, ultimately resulting in positive outcomes in both schedule and budget. When comparing 2D and 3D design, Expert 2 notes that construction errors caused by design mistakes have been reduced by 80%. This has been demonstrated by comparing the number of change orders. Expert 2 explain:

"Problems are much easier to identify in 3D, that's not the case with 2D. In 2D, issues often only become apparent during execution, when they are far more costly and time-consuming to fix."

However, the perceived value of using BIM models in the construction phase is not always evident to clients in this study. Clients 2 and 3 stated that they do not fully utilize BIM models during the construction phase. Since they focus on less complex facilities, such as rental units, condominiums, and warehouse spaces, they believe that the cost of developing a fully detailed BIM model does not justify the investment, given their relatively low rate of construction errors.

4.3.2 Updated Models

Several experts emphasize the importance of working with updated models and drawings. Construction Project Manager 3 and Expert 3 points out that an issue in construction is the use of outdated printed drawings on site, often because the latest documentation hasn't been properly distributed. Experts describe how CDE:s can be used to generate drawings directly from the BIM model, which means that the drawings are filtered views of the model data. Expert 3 emphasizes that live BIM models ensure that the entire project team has access to consistent, real-time information. Any updates made to the live model are automatically reflected in the 3D view, removing the need to reprint drawings and minimizing the risk of outdated information.

"A drawing provides static information, sometimes limited by what fits onto a page, but with live data, you can be confident you're always working with the latest model."

Expert 1 points out that today models are often designed before construction starts, and updated first with the as-built documentation in the end of the construction project. In the best-case scenario, changes are captured in the final as-built drawings, but often they are not even included then. If changes made during construction are not documented in the model, the model quickly loses relevance. Despite this, CDE:s are most commonly used without live data. Expert 1 explains:

"An IFC file isn't live data. Ideally, you want live data. Things are changing constantly, the designers keep working, construction evolves, and new requirements from the client come in."

In order for an IFC file to be updated, it must first be synchronized with the design software. Expert 1 points out that it is problematic when original files are stored on the project designers' file servers, preventing other stakeholders from accessing live data. This creates a dependency on the designers to frequently synchronize their work. Expert 4a stresses the importance of working with centralized data, enabling a shared and synchronized view of the project through cloud services. They share the experts view of the current state where many still work by exporting IFC files:

"We are currently somewhere in an in-between state where people are hesitant to fully commit to centralized live data. Instead, partial solutions are used, some teams work locally and deliver files separately, creating two different realities."

From a construction management perspective, not having access to the original files can be challenging, as there is often a need to further process and adapt the models for the construction phase. Expert 2, who has made significant progress in working with digital construction management, uses ACC in the design phase, which provides direct access to the original files. However, to bring the model into construction, StreamBIM is used, meaning that an IFC export is required to the CDE. Future more, in the digitally mature Norwegian hospital project, IFC files were automatically synchronized with StreamBIM three times a day, which according to expert 6a was sufficient to keep the drawings up to date.

Expert 1 further notes that one of the major advantages of working with CDE:s is the improved traceability. Changes can be tracked over time, making it possible to see exactly what was changed and by whom, something that is not possible with static drawings. Several experts claim that another major advantage of updated live models is that design work can continue in parallel with the start of construction, allowing for more flexible and dynamic project development adapted to the conditions on site. However, even when working live, Expert 4a notes that most of the design work still needs to be completed before construction begins. Building too closely behind ongoing design work can lead to costly rebuilds, as models often continue to evolve during the design phase.

4.3.3 Ownership of the BIM Model

Several interviewed experts claim that it is crucial for the client to clearly understand who owns the BIM model at each stage of the project. According to Expert 4a and 4b , during the design phase, ownership typically lies with each discipline responsible for their part of the model. They explain that in the projects they have been involved in, ownership of the digital model has varied. In some cases, the client owns the model, while in others it is controlled by the contractor. At the point of handover, however, all BIM models should be transferred to the project owner. According to Expert 4a, if the client does not have ownership of the model from the beginning, multiple versions of the project reality can quickly emerge, leading to inconsistencies and coordination challenges. All four interviewed clients confirmed that they have ownership of their BIM models once the building is completed. Expert 1 highlights this as a key strategic concern:

"The client should always retain ownership of the model, both during the project and after its completion. Assigning ownership to the contractor poses a risk of information loss or restricted access.

Access to the BIM models is also influenced by who holds the licenses for digital tools and visualization CDEs. In some of the interviewed projects, the consultant or the contractor held the license, limiting the client's ability to independently access and navigate the model. This dependency on third parties can complicate the client's management of their own building information.

4.4 Facility Management

CDEs play an important role in linking the flow of information from the construction phase to the operation and maintenance stage. Several interviewees point out that being able to create, store, and access technical documents using digital tools can help to make operation and maintenance work more efficient. This is valuable for the client and the long-term use of the building, and a requirement for digital twins.

Several construction project managers describe a clear gap between the detailed information created during the construction phase and the small amount that is actually passed on to the operations phase. Photos and documents from questions that came up during construction, which could be useful for future management, often stay on the construction project managers' hard drives even after the project is handed over. CDEs are important to keep structure and continuity in the handover. Expert 5 explained that old issues still remain in the CDE even after they are approved. This makes it possible to go back and find useful information during the operations phase if it is stored correctly.

Several interviewees have seen the use of BIM models during the facility management phase. Client 1 describes how they are initiating a system where after project completion, the model is transferred to the facility management system, where as-built documentation and technical information are linked to the BIM model. By using the digital model for facility management, it becomes easy to retrieve information about everything from the construction and materials of components to warranties and installation dates. Client 1 explains:

"All as-built documentation must be integrated into Planon, so that if the operations team reports, for example, that a light fixture isn't working, they can simply click on that fixture in the model, which will automatically generate a maintenance request for the facility management team. The model thus becomes the foundation for a case management system."

Expert 2 designed a feature where clicking on an installation provides details about who installed it, what the warranty terms are, and how the system should be maintained that can be used in facility management. However, this approach often requires some processing, since the BIM model usually contains more information than is needed for facility management purposes. At Client 1, a dedicated BIM coordinator is responsible for defining requirements and validating the model during project handover.

Expert 2 emphasizes that while this approach creates clear value, it also requires the client to have well-defined requirements and processes regarding what information should be delivered for facility management. According to Expert 2, it is crucial that working methods and information requirements are clearly defined from the project initiation in order to fully realize the benefits of the digital technologies in construction and facility management.
Client 3a confirm that they have the authority to set requirements regarding the extent to which the BIM model should be utilized. However, Client 2 highlights a challenge:

"As a facility management organization, we would need to fundamentally change our way of working to fully utilize intelligent models connected to our buildings. Considering that we have 80,000 old apartments with unintelligent 2D drawings, and only build 500 to 1,000 new homes per year using 3D models, there would be a major need to adapt our entire system to support model-based facility management in the future."

4.5 CDE

This chapter presents opinions and personal experiences from using the CDEs and how they can create value for the client.

Attitudes toward CDE:s vary among the interviewees, and it is evident that clients perceive the value of such tools differently depending on the type of buildings they work with and their level of involvement in the construction process. Several construction project managers express a generally positive view of the potential of digitalization but also point to challenges related to training, support, and the lack of standardization within WSP. Construction Project Manager 3 believes that digital tools can be highly useful, but that there is no shared understanding of their benefits or how to implement them. He emphasizes that the responsibility to learn lies with the individual:

"You don't know where to start, there's no clear path for where to begin or what you can use. We have a guy in our department who works with the digital stuff that you can ask, but he needs to have time, and I need to have time, and then we have to sync and prioritize it, which often doesn't happen."

In addition, several construction project managers highlight the need for standardization. Currently, they are required to work in different digital project portals depending on the client, which leads to a lack of structural consistency across projects. Construction Project Manager 1 points out that inappropriate users sometimes gain access to too much information in shared portals, which underscores the need for stricter access control. He suggests appointing a designated person responsible for metadata and user training within the CDEs.

Among clients, there are both strong advocates for digital tools and more selective users whose engagement depends largely on the nature of the project. Client 4 states that the CDE has been a crucial tool for project execution and emphasizes that the BIM model is essential for ensuring constructability in complex projects. Client 2, on the other hand, works primarily with simpler buildings involving limited technical complexity. He argues that the economic benefit of digital platforms is not always justified in such contexts. In his view, communication functions well without the aid of digital tools, and since their projects typically involve few changes, he does not perceive the same value in adopting digital systems.

According to Expert 1, a digitally mature Norwegian hospital project succeeded in reducing both costs and construction time by approximately 30 percent, which he argues demonstrates that investments in digital design pay off through fewer errors and more efficient construction. Moreover, expert 5 notes that CDEs can still provide value even without the integration of a BIM model. The CDEs supports communication, issue tracking, and information sharing based on 2D drawings, thereby offering construction benefits even when projects are not designed in 3D.

Client 4 says that the effectiveness of digital tools depends on digital competence within the team. She argues that it is crucial for users to trust the accuracy of the BIM model, because if the model is perceived as unreliable, confidence in the tool quickly erodes, which can undermine the entire project's digital workflow:

"You need a good BIM coordinator who works closely with the designers and the manager to ensure that you get a proper level and a correct model from the start, because if you start to realize that things do not match in the 3D model, you no longer dare to trust it, and then you have a problem."

4.5.1 StreamBIM

Several experts describe how StreamBIM has been used successfully in projects at the forefront of digitalization. Expert 2 explains that, as a construction management company, they use StreamBIM throughout the entire process, from coordination and clash detection during design to all communication during the construction phase. By consolidating all information on a single platform, they avoid having to manage separate portals and workflows for each individual project, which simplifies the process as many actors come and go during construction.

According to Expert 2, a key reason the company chose StreamBIM was its measurement capabilities within the BIM model, which they considered a fundamental requirement during the construction phase:

"It actually started with one requirement, and that was that it should be possible to measure well in 3D. Taking measurements and things like that is extremely important in construction , and it's incredibly easy in StreamBIM to extract measurements."

Several experts also emphasize user-friendliness in StreamBIM. Expert 3 states that StreamBIM is user friendly for the construction workers on site, which is crucial for ensuring that the tool is actually used in practice. Both Expert 1 and 3 point to the platform's filtering function as particularly effective. According to Expert 1 and 3, StreamBIM is designed in an easy to find format, with the vision that users should be able to find the right information in just three clicks.

4.5.2 Dalux

Dalux is widely recognized and used across the industry, and during the interviews, several participants noted that most professionals have at least some experience with Dalux. Construction project managers frequently mentioned that Dalux is commonly used for inspections, and even Client 2, who represents an organization that is less digitally mature, described it as an efficient and clear tool when used by inspection personnel, particularly when issues are related to photos, which improves transparency.

The Dalux BIM Viewer was highlighted by several experts for its strong technical performance. Expert 5 emphasized that one of the main advantages is its ability to handle very large models, while Expert 3 noted that the viewer is quick and excels at tracking changes between different versions of the model.

Client 4, who actively uses Dalux during the construction phase, sees it as an effective communication tool and especially values the ability to view the BIM model alongside the drawings in the same interface. The overall user-friendliness of Dalux was described as a key strength by many of those who use it regularly in their projects.

4.5.3 ACC

ACC was mentioned by several experts as a CDE with significant breadth, primarily due to its integration with Autodesk's wider software ecosystem. Expert 3 highlighted that ACC's main strength lies in its connection to tools such as Revit.

Expert 3 noted that although ACC covers a wide digital scope, Autodesk's tools are generally more focused on the design phase than on the practical needs of construction site management. Expert 4b reinforced the view that Autodesk's heritage is rooted in design, but saw this as a potential strength. He emphasized ACC's ability to connect designers and builders by enabling data feedback from the construction site back to the model. For example, if a door is found to be placed 30 cm incorrectly, this issue can be logged in ACC and synced directly back into Revit, allowing the architect to update the model.

Another function Expert 4b highlighted is ACC's digital twin integration via Autodesk Tandem. When a building is handed over to its owner or facility manager, all data collected in ACC can be transferred with a single command into Tandem. This creates a digital twin that can be connected to sensors and live data, enabling real-time monitoring and operation of the building after handover.

However, the interviews also revealed several limitations. Expert 1 pointed out that while ACC enables cloud-based access to and editing of original files, it is not specifically tailored to the Swedish market. He explained that Autodesk designs for a global audience, and as a result, local standards, processes, and terminology are not always well integrated. Overall, interviewees indicated that the use of ACC in Sweden is currently limited.

4.6 Digital Tools

During the interviews CDE:s were highlighted as the most relevant tools for digitalization in construction project management. However, 360-degree cameras and AI were also briefly mentioned by the interviewees.

4.6.1 360 Camera

Expert 2a described how they used 360-degree cameras to visually document the progress of projects. Walking through the construction site with a 360-degree camera, often mounted on a helmet, the camera continuously captures images. These images are then connected to CDEs and linked to specific coordinates within the BIM model. Expert 2a and 5, means that 360-degree cameras are useful in to visually track progress over time, visualize different stages of construction, and compare real site conditions with the BIM model. The images also serve as valuable documentation during inspections or quality checks and can be used during handover to facility management. For example, they allow project teams to view installations that have since been covered, providing essential insights that would otherwise be inaccessible. Expert 5 also emphasizes how the images can be used to create as-built documentation or adjusting design drawings.

Client 1, although not having used the 360° feature, sees its potential in renovation projects, particularly for tracking what has been built or hidden inside walls. They decided not to use it due to the complexity of the space, with many corners and tight areas, but acknowledged its potential value for documenting major changes and communicating the scale of completed work. However, the 360° camera require additional investments. Client 4 explained that they chose not to use it in their current project due to cost and limited perceived need, but added that the feature will be evaluated at the end of the phase to determine whether it should be implemented going forward.

4.6.2 AI

Construction project managers express both curiosity and skepticism regarding the role of AI in their work. Several see potential for AI to support tasks such as meeting minutes, text processing, and checklists, but most do not actively use these tools today. Project Managers 1 and 3 have tested Copilot for meeting transcription but encountered technical issues that hindered further adoption. Meanwhile, Project Manager 4 has had positive experiences using AI tools to rephrase and adapt text for different purposes. He also sees potential in using AI to edit images in tender documents, such as removing unwanted objects. Expert 4b explains that Autodesk currently offers eleven AI features, some embedded in ACC and others in design tools like AutoCAD. For example, AutoCAD uses AI to detect repetitive tasks and generate scripts. In the Nordic region, AI solutions are also being developed to interpret requirement specifications and convert them into actionable checklists. Similarly, Project Manager 3, when speculating freely about future applications, imagined that AI could be helpful in generating project-specific checklists, suggesting it could produce tailored lists of what to inspect depending on the type of project. At the same time, Project Manager 1 remains skeptical of using AI in construction project management as he prefers to maintain full control over his role and feels that AI lacks the ability to capture nuances and prioritize important issues.

4.7 Contract Structure

Several interviewees highlighted the connection between contract structure, payment model, and the level of digitalization. Client 2 explained that their projects are almost exclusively procured based on lowest price and fixed-price contracts which results in limited incentives to invest in more advanced digital tools. Since procurement is based on performance specifications, Client 2 is less concerned with how the work is executed, arguing that it is the design-build contractor who benefits from fewer errors and change orders resulting from a well-developed BIM model.

Expert 4b expanded on this issue, arguing that current contractual frameworks and business models often hinder digital progress. He explained that digital tools are still seen as an additional cost rather than a long-term investment, and that the prevailing compensation structures in the industry do not reward increased efficiency. "Why should I improve if fewer hours means less payment?" he noted, pointing to the fact that existing business models do not support a digital way of working. For digitalization to gain real traction, he emphasized, all parties must benefit from it. He highlighted the "alliance model" used in Finland, where multiple companies share both risk and profit, creating joint incentives to improve performance. By contrast, expert 4b says that the current procurement practices often reward inefficiency:

“Today, companies make money on mistakes. In procurement, they look for loopholes.”

Client 3a explain how they almost always work with design-build contracts, particularly in logistics projects where the buildings are relatively simple. As such, the extent of digitalization is partly dictated by the contractor’s level of ambition. However, Client 3a also emphasized that it is the client’s responsibility to set clear digital requirements. However, ultimately, the contractor’s digital maturity and the nature of the project determine the extent to which digital tools are applied in practice.

Expert 6a described how they used multiple prime contracts in a digitally mature project, which allowed the client to retain control over designers and documentation. The client also set up digital requirements in the contracts, for example, replacing traditional drawings with BIM models as contractual documentation. The contracts also included explicit requirements for digital collaboration and systematic training in digital workflows. In this way, the contract form itself became a prerequisite for managing the flow of information digitally.

Expert 2 described how their work in CM involves signing separate contracts with each trade. This approach facilitates digital coordination, where models are prioritized over drawings. Through the CM structure, where the client maintains control, it becomes possible to work systematically with digital tools in ways that are more challenging in traditional design-build contracts.

Expert 3 points out that one key reason why the digitalization of construction projects has progressed further in Norway than in many other countries is the contractual flexibility that allows the model to be used as the legal basis instead of traditional drawings. This creates a strong incentive to work model-based throughout the project. In countries where contracts still require the construction of drawings regardless, the motivation to adopt a fully model-based workflow is weaker, as the model is then seen as a complement rather than the primary source of information.

5

Analysis and Discussion

In this chapter, we analyze the results in relation to the theoretical framework and discuss our findings on digital solutions, with a focus on CDEs. Our main findings indicate that CDEs contribute to more structured communication and enhance the quality of the BIM model. This, in turn, creates value for clients by reducing information loss and minimizing construction errors. Furthermore, the chapter addresses key challenges related to the implementation of digital solutions, including mindset-related challenges and practical issues such as model ownership and licensing.

5.1 Communication

The role of the construction project manager within a consulting company centers around representing the client's interests and ensuring that project goals related to time, cost, quality, and functionality are met. This role is communicative intensive, requiring the project manager to act as the central point for stakeholder interaction and day-to-day site oversight. Much of the value a construction project manager brings to a project lies in their ability to manage information flows between actors, ensure that updates are accurate and timely, and turn insights from the construction site to informed decision-making at the client level. This also means that the construction project manager's credibility and perceived value depend on their ability to stay informed, interpret conditions accurately, and maintain trust with the client. Transparency and structure in communication can help strengthen trust and improve the client's understanding of ongoing work. Digital tools support this process by offering ways to document, track, and share information in a more organized way. This means that by making use of digital tools, construction project managers have the potential to strengthen the value they give to their clients.

Obododike Ekwuno, 2022 emphasizes that open and interactive communication is a critical success factor in construction projects. It supports stakeholder alignment, reduces misunderstandings, and creates conditions for proactive decision-making. However, findings from the interviews reveal that this ideal is far from reality in many projects. One of the challenges mentioned by both construction project managers and clients is that communication today happens in too many places which leads to difficulties in tracking, verifying, and retrieving information. When project data like decisions, questions, and task details are not centralized, there is a high risk of fragmentation and loss, reducing the effectiveness and perceived value for the client.

Several participants expressed that they see a clear benefit in centralizing communication, but also acknowledged that there is a lack of knowledge and routines to establish the necessary structure. As a result, important project information risks being stored in isolated email threads or individual folders, making it inaccessible to other team members. This creates information silos and weakens traceability and collaboration. This aligns with Gamil and Abdul Rahman, 2018 research findings that indicate that fragmented communication negatively affects project performance, and limits the client's ability to manage time, cost, and quality effectively.

During interviews, CDEs were emphasized by digitally mature clients and experts as essential tools for enhancing communication quality. This observation aligns with existing literature by Obododike Ekwuno, 2022 that highlight the role of technology in supporting effective communication in construction projects. These platforms enable structured, traceable, and centralized communication, reducing the risk of misunderstandings and loss of information. Issues can be tracked from initiation to resolution, tasks can be assigned to specific stakeholders, and documents can be accessed and updated in real time. This level of transparency supports better follow-up, creates accountability, and contributes to a more collaborative project environment. The interviews also revealed a common misunderstanding that CDEs are only valuable when a well-developed BIM model is available. Expert 5 specifically emphasized that CDEs can be used even when only 2D drawings form the basis of the project documentation. The platforms facilitate communication, coordination, and information sharing without the need of complex BIM models, and can therefore add value to any construction project.

5.1.1 Site Meetings and Site Visits

One area where the impact of improved communication is especially evident is in the context of site meetings. These meetings remain an important mechanism for coordination during the construction phase and were described by interviewees as essential. However, construction project managers expressed concerns about the lack of structure in how meetings are documented and followed up. Digital tools offer potential to improve both the structure and outcome of site meetings. By integrating digital protocols with project platforms, it becomes possible to ensure that all issues are logged, assigned, and followed up systematically. Notifications alert the responsible parties, improving response times and reducing misunderstandings. In addition, using the BIM model as a visual aid during meetings strengthens the shared understanding among participants and ensures that discussions are grounded in accurate, spatially-relevant information.

These findings align with the theory from Aliakbarlou et al., 2018, defining client value as more than just the achievement of budget, time, and quality goals. Soft values, such as transparency, collaboration, and communication, are increasingly recognized as essential to delivering value. Improved communication enabled by digital tools contributes directly to these softer values, building trust, reducing conflict, and supporting more predictable project outcomes.

Regular site visits represent another opportunity for communication and coordination. However, as described by several construction project managers, the current approach to site visits often lacks systematic documentation and integration with the broader project communication. By integrating site observations into digital systems, the need for handwritten notes, delayed report writing and reliance on individual memory is minimized. Instead of spending time on non-value adding activities, such as searching for the right location or rewriting notes into formal protocols, construction project managers can focus on identifying and solving issues directly. The improved clarity and traceability offered by these digital tools not only increase efficiency but also align with Ismail and Mohd Yusof, 2016, emphasizing the importance of eliminating nonvalue-adding processes, as they do not contribute to the final product or outcome of the project and are seen as waste for the client.

5.1.2 Time Plan

One of the construction project managers tasks is to monitor that the contractor follows the time plan. However, interviews with construction project managers revealed that this oversight is often imprecise and progress tracking is a general impression rather than a detailed assessment. This makes it difficult to detect delays early and may contribute to the accumulation of unresolved issues that affect overall project timelines. Several experts described how digital tools can support more precise monitoring through status codes linked to individual components in the BIM model, providing a real-time picture of construction status. This level of detail, however, requires significant digital maturity. In tools like Dalux and StreamBIM organizations must develop their own integrations, linking the project model with external systems capable of managing and visualizing completion status. While this is technically possible, it demands both technical competence and organizational commitment.

The potential value of such integrated systems is significant. If completion tracking can be linked directly to the time schedule, and also to the project budget, it becomes possible to detect delays immediately and quantify their consequences. ACC, for example, offers a tool for connecting scheduling and budgeting functions, allowing project teams to see not only whether tasks are completed on time, but also how delays impact cost projections. From a client perspective, it contributes to higher perceived value, as it minimizes the likelihood of surprise delays and helps keep the project aligned with its contractual commitments. According to Aliakbarlou et al., 2018, reliability is a factor in value creation that has grown in the last decades. By basing follow-up on verifiable data, the construction project manager can deliver more reliable reports, which in turn strengthens trust with the client, whose ultimate goal is that the project is delivered on time and within budget.

5.2 BIM Models and 3D Review

As mentioned in several interviews by construction project managers, the BIM models show great potential to create a common understanding of what is to be built as well as provide the construction site with updated drawing information. Having a well-developed BIM model also creates value for the customer by reducing design errors and therefore reducing construction errors. According the Cost of Change Curve in the theory chapter, finding errors in the design phase will lower the cost of changes and therefore reduce the financial burden on the client. However, expert interviews revealed a major disconnect between how BIM is used in design versus construction. While most projects are now designed in 3D, this digital richness is often lost when the model is converted into 2D drawings for use on site. This transition breaks the information chain and weakens the potential of BIM as a unified information hub. Several experts emphasized that CDEs offer a solution to this problem by enabling construction teams to use the model directly during construction.

5.2.1 BIM Model Quality

An observation in this study is that high-quality design documentation and well-developed BIM models with less design errors provide significant value to clients. If the model is also updated with changes made during construction, the reliability of the as-built model increases, providing long-term value for the property owner. This is clearly illustrated by the case of Expert 2, where a strong focus on model quality and less design errors led to a reduction in change orders by up to 80%. This contributed to their ability to deliver projects on time and within budget. This aligns with the Cost of Change Curve, which demonstrates that the cost of correcting errors increases exponentially the later they are identified in the project life cycle. Detecting and resolving issues during the design phase, rather than during construction or facility management, reduces the risk of remuneration costs.

Despite this, drawing errors remain common in the construction industry. The results suggest that the benefits of investing in detailed and coordinated models are not always immediately evident to clients. This makes it difficult to justify to the client why they should pay extra for something that does not appear to deliver immediate value, such as a detailed BIM model compared to basic 2D drawings. However, the perceived and actual value for clients don't always align, as the positive effects, such as fewer change orders and reduced clashes on-site, typically become apparent only at later stages of the project. Furthermore, some organizations that already experience low costs related to change orders during construction may lack incentives to invest in complex BIM models. For these companies, the cost of resolving issues during construction is perceived to be lower than the upfront investment required for advanced digital modeling. This reflects a short-term economic view that overlooks the long-term benefits of minimizing operational costs and enhancing the end-user experience.

A challenge highlighted by Expert 2, is the lack of clearly defined construction requirements and structure during the design phase. Models created for visualization or clash detection rarely contain all data needed for construction. As a result, models are often not adapted for construction, which reduces their usability in this phase. Designers need to have clearly defined requirements in order to create digital models adapted for construction. This is also empathized by Disney et al., 2023, stating that designers need to produce a BIM model that is usable in construction.

Several interviewees also highlighted the value of the 360° cameras and point cloud scanning to create accurate models of existing buildings. The use of these cameras may increase since they can be especially valuable for remodeling building projects with missing or outdated documentation, that are to be rebuilt. The 360° cameras also allow a reliable as-built model to support facility management and reuse assessments.

5.2.2 Economical Incentives for Digital Modeling

The economic incentives in construction contracts emerged as a recurrent theme in informal discussions throughout this work and were addressed by some interviewees. In design bid build contracts, where the contractor has not participated in the design phase, there is a financial incentive for the contractor to identify flaws in the design documentation as these errors often become opportunities for profitable change orders. From this perspective, clients can face higher project costs if the BIM model is not fully completed during the design phase because clients are in a bad position to negotiate with the contractor when the construction has already started. Therefore, investing in a detailed and coordinated BIM model can be a strategic advantage for the client. By minimizing design errors, the potential for costly change orders during execution is reduced. However, in design build contracts with fixed price the economical incentives of a detailed BIM model potentially falls to the contractor, since design errors must be paid by the contractor themselves.

Clients and experts described how CDEs and BIM models are seen as an expense rather than an investment among some clients. Although using digital tools can reduce costs over time, the initial investments in digital systems, training, and requirement-setting must be justify. Designing high-quality, detailed BIM models to meet the requirements for using BIM in construction also increases the design costs. The return on investment (ROI) is not always immediately visible, leading decision-makers to prioritize short-term solutions over long-term digital strategies. This is supported by Tangkar and Arditi, 2000, suggesting that clients' limited experience and technical understanding of construction processes can be a major barrier to digital adoption. Without the knowledge to assess how digital tools and BIM models improve coordination, reduce errors, or enhance long-term asset management, clients may hesitate to fund such initiatives.

5.3 Digital Solutions

According to Marnewick and Marnewick, 2022, effective digitalization requires both structural support and organizational alignment. Without a clear strategy and internal support structure, the burden of digitalization falls on individual employees, making it unlikely that tools will be used consistently or effectively. This was highlighted by several construction project managers, who expressed that they lack sufficient support in using digital tools, making it challenging to integrate them into daily work routines.

Utilizing the model during the construction phase is a critical step toward achieving Total BIM, as it ensures that information generated during construction, such as changes, decisions, and inspections, is fed back into the model and retained for future stages. The interviews reveal that companies that took an early initiative and were willing to fully commit on digital solutions are seeing benefits in terms of improved coordination, communication, and process efficiency. A strong example of that is a Norwegian hospital project where a Total BIM approach, according to Expert 1, lead to 30 % saving of the project budget. Furthermore, the project was completed 30 % ahead of time. At the same time, some clients reported that they are actively using CDEs, even if not to their full potential. This suggests that the industry as a whole may currently be transitioning from early adopters to the early majority stage in the Technology Adoption Curve in the theory chapter. If construction project managers does not engage proactively with digital transformation before this shift progresses further, there is a risk that they fall behind and can not provide the services wished for by the client.

5.3.1 Embracing Digital Solutions

Despite the recognized potential of digital tools in construction, several barriers continue to hinder the adoption. A key barrier to successful digitalization, as highlighted by Marnewick and Marnewick, 2022 and in interview data, is mindset. Several experts pointed out that individuals often resist changing their established ways of working, perceiving traditional methods as sufficient. This was also confirmed by construction project managers, who noted that colleagues frequently struggle not only with adapting to digital tools but also with understanding how to use them. Their lack of digital knowledge creates further resistance, as unfamiliar systems are perceived as difficult. Many challenges related to digital adoption seems to be people-oriented and rooted in organizational culture, and without a clear understanding of why new tools are introduced and how they add value, employees are unlikely to engage fully with digital processes.

To effectively utilize CDEs a high level of digital maturity is required within the project team. While the benefits of these tools are well-documented, the implementation phase of the tools demands a high level of expertise. Setting up the CDEs, inviting participants, and establishing clear communication pathways between different actors must be carried out with precision and technical competence. It is crucial that users are not exposed to negative experiences with the system, as this can lead to resistance and reduced adoption. Therefore, having a digitally competent support team is essential to ensure a smooth and user-friendly experience with the CDEs.

5.3.2 Common Data Environments

The study reveals different patterns in how CDEs are used and perceived within the industry. While several interviewees shared positive experiences using Dalux and StreamBIM in ongoing projects, no clients or experts interviewed had direct experience implementing ACC in a live construction project. As a result, insights on ACC are primarily based on expert-level knowledge of the tool's theoretical advantages, rather than practical feedback from project use. However, experts highlighted that one of ACC's main strengths lies in its integration with the broader Autodesk ecosystem. This suggests that ACC may be particularly well suited for office-based roles, such as design coordination and project management, especially when working with Revit and other Autodesk tools. This observation supports a expert opinion in this study, that Autodesk products may be more useful for professionals working on the design and documentation side of the project, whereas tools like Dalux and StreamBIM appear more practical and accessible for on-site use by construction teams.

One notable difference between the CDEs relates to market adaptation. ACC is not fully tailored to the Nordic market, and according to experts, this has limited its adoption in Sweden, where tools like Dalux and StreamBIM have already established strong footholds among both clients and contractors. In many projects, it is difficult to introduce ACC once another platform is already in use, and for optimal project performance, it is often preferable that all stakeholders work within the same digital environment. Additionally, the absence of fully developed 3D measurement functionality in ACC, which remains in beta according to theory, may be one of the reasons other platforms have gained a stronger presence in the region. Although this limitation was not raised directly in interviews, several experts emphasized that the ability to measure within the BIM model is a critical feature for effective on-site use.

While core functionalities exist across all three CDEs, the way these functions are implemented and used differ between them. For example, ACC's Asset module performs similar functions to the integration between StreamBIM and dRofus used in the Norwegian hospital project described by Expert 6a, where installation status was monitored using custom status codes tied to model objects. A notable strength of ACC is its broader range of built-in tools and pre-developed APIs, which allow organizations to extend the CDEs into areas like budget tracking, scheduling, and advanced project analytics. If an organization has the capacity, willingness, and financial resources to invest in a customized ACC environment, the platform can offer a wide and powerful tool set that exceeds what Dalux and StreamBIM currently provide out of the box. While similar functionality can technically be achieved in

Dalux or StreamBIM through third-party integrations the APIs or plugins are not as readily packaged and provided as in ACC.

However, the fact that ACC is not widely used in the Nordic market indicates that usability and accessibility are key factors in platform adoption. Both Dalux and StreamBIM were repeatedly described in interviews as user-friendly and easy to integrate into everyday construction workflows. Dalux, in particular, has evolved from a document-focused tool to one that now offers increasingly strong model integration, challenging StreamBIM's earlier dominance in that area. However, StreamBIM has been noted for hosting its data on Swedish servers, which may offer an additional layer of appeal in public or sensitive projects with strict security and data governance requirements. Ultimately, no single platform can be considered the best overall, their effectiveness depends on the organization's capacity to implement and support the tool.

5.3.3 Digital Tools

One additional tool that did receive repeated mention during the interviews was the 360-degree camera. Respondents who had worked with this technology highlighted its value in documenting the progress of a project throughout the construction phase. The ability to visually track changes over time and compare current site conditions to the BIM model was described as especially useful for coordination and quality control. Moreover, the archived images were seen as a valuable reference in the case of disputes or questions that arose after project completion. For construction project managers, whose role is to monitor the site, ensure that contractors follow the plan, and report back to the client, 360-degree photography presents a promising support tool. Several construction project managers described how they routinely take their own photos to document progress and potential issues. The use of 360 cameras can be seen as a an extension of this practice, allowing for broader coverage, improved traceability, and more reliable documentation. A key advantage of the 360-camera functionality is that the images can be directly linked to the BIM model and specific locations within the project, making it easier to navigate and understand exactly where on site an issue or observation occurred. In doing so, the technology may reduce the risk of overlooking problems during construction and improve the efficiency of site follow-up.

Although the study initially aimed to explore a broader range of digital solutions, interviews, particularly with experts, consistently focused on CDEs. Tools like VR, AR, and AI were mentioned only in passing, suggesting that these technologies have yet to achieve widespread relevance within construction project management. While AI is widely discussed in the industry and holds significant potential, its current application in construction management appears limited. So far, its primary use has been as a text-based assistant for generating or reviewing documentation. However, the results suggest that new AI solutions are currently under development, and tools capable of interpreting requirements and generating checklists will most likely be widely used in the future. The theory shows that VR and AR has great potential, especially in the combination with CDEs, but interviews revealed that the technology is not yet ready. Expert 2a mentioned that they keep an eye out for VR and AR solutions that can create value for them or the client organization. However, it can be argued that the 360° camera integrated with the BIM model in the CDEs is, if not fully AR, at least inspired of AR technology.

5.4 Post Construction

A construction project manager in a consulting firm acts on behalf of the client, with a key responsibility to define the project's objectives in terms of function, time, cost, and utility. As highlighted by Walker, 2015, this means that the role includes making sure that the project fulfills its intended purpose and creates long-term value for the client also post construction. Achieving this outcome requires early and proactive involvement from the project management team to ensure efficient use of the BIM model also after the construction phase is completed. The construction project manager's responsibility for managing digital information throughout the project therefor becomes increasingly significant. A project manager working within a consultancy can play a key role in supporting the client in implementing digital models or digital twins across both the construction and facility management phases. This responsibility extends beyond technical implementation and includes structuring workflows, coordinating information requirements, and ensuring that the model remains accurate, relevant, and ready for handover to the operational phase. By strengthening the continuity of digital information from design through to operation, this approach enhances long-term project value.

5.4.1 Facility Management

According to Islam et al., 2019 some of the main cost drivers in facility management are design errors caused by incomplete drawings, insufficient specifications, and a lack of coordination during the design phase. Operational costs are also negatively affected by the absence of structured facility management databases, lack of maintenance plans, unclear client requirements, and poor communication between stakeholders. The results of this study indicate that CDEs and well-structured BIM models can improve all these operational challenges, as mentioned by Client 1 and Expert 2. If the the BIM model is also maintained throughout the construction process and carried forward into facility management it holds more information and have even grater potential to improve facility management and lower the costs in the operational phase.

Client 1 described how the digital model can be actively used in facility management by linking technical documentation to components in the model, enabling quick access to installation data, warranty terms, and maintenance routines. Having a digital model in the facility management team creates value because the BIM model can provide a clear overview of warranty periods for different components, which is especially valuable during the initial years after handover. When warranties are linked directly to objects in the model, faults can be resolved more efficiently,

reducing costs and improving service quality.
The usability of the model for facility management is highly dependent on the quality of handover. If changes made during the construction phase are not documented in the model, it quickly becomes outdated. This leads facility managers to lose trust in the model and instead rely on alternative sources of information.

One limitation for implementation of CDEs in the post-construction phase is the generally low level of digital maturity within many facility organizations. Many technical managers still rely on 2D drawings, paper-based systems, or unstructured file storage, making it difficult to integrate BIM models into their daily operations. As Client 2 states in the study, transitioning to model-based facility management would require the organization to fundamentally change their way of working, a shift perceived as demanding in terms of both resources and competencies. By making BIM models in facility management teams common practice, many of these opinion and knowledge related challenges may disappear over time, when the value is visible for the team.

5.4.2 BIM as an Enabler for Digital Twins

Having high-quality documentation and well-developed BIM models are particularly relevant in the context of digital twins. The result shows that transitioning from a BIM model to a digital twin is feasible, but it requires clear ownership, structured workflows, and long-term strategic planning. Interviewees also highlighted challenges in adapting existing systems, especially when dealing with older building stocks or legacy processes that are not compatible with model-based operations. This illustrates a gap between technological potential and practical implementation. Although digital twins can enhance decision-making and reduce long-term costs, organizations often lack the incentives or understanding needed to make the necessary early investments. For digital models and twins to deliver their full value, they must be supported by contract structures, defined digital requirements, and a better understanding and ability among clients to work with digital tools.

5.4.3 BIM as an Enabler for Reuse

Reuse of building materials is increasingly promoted as a key strategy to reduce the climate impact of the construction sector. In this context, BIM play an important role by supporting the reuse process. For the BIM model to effectively support reuse, models must be kept accurate and up to date during the construction phase. As theory shows, incomplete or missing as-built models are still common and many reuse efforts still rely on manual surveys, which are time-consuming and less reliable. To realize BIM's full potential in circular construction, continuous model maintenance and structured information delivery throughout all project phases are essential. Beyond environmental benefits, reuse also offers economic advantages for the project owners. Since materials account for a large portion of construction costs, reusing components like doors or facade elements can reduce expenses. Less waste also lowers transport and disposal costs, while supporting sustainability certifications and access to green financing.

5.5 Beneficiaries of Digital Implementation

While clients are typically the ones who must invest financially in new technologies, Tangkar and Arditi, 2000 suggests that they are also the primary beneficiaries of successful digitalization. However, this connection was not always reflected in the interviews. For instance, one client argued that in design-build contracts, the benefits of digital solutions often fall to the contractor rather than the client, reducing the client's motivation to invest in such tools. However, this client focused primarily on short-term budget constraints, rather than the long-term advantages that digital tools can offer, such as improved documentation, reduced operational errors, and enhanced facility management during the operation phase.

In the interviews several construction project managers pointed out that they are dependent on client willingness and budget. This highlights the limited influence consultants often have when acting on behalf of clients, particularly within large organizations that already have established internal processes, decision-making structures, and sometimes project platforms. In such contexts, the consultant's ability to introduce new digital tools or workflows may be limited by the client's existing systems and routines. In contrast, in smaller organizations or in cases where digital structures are not yet fully in place, consultants with strong knowledge of digital tools can be seen as valuable contributors, capable of supporting the client's development both in the short term and as part of a broader digital transition.

Tangkar and Arditi, 2000 describe that construction project managers have the potential to ensure successful digital adoption, acting as key facilitators between client needs and technological solutions. However, the extent to which construction project managers can fulfill this role varies depending on the type of consultancy firm. Construction management firms that specialize in digital project delivery have a great opportunity to influence the construction process. This was supported by the interviews, where construction management firms, that had invested in digital strategies, reported successful implementation of digital tools in complex projects. These cases demonstrate that when consultants possess the expertise and are given sufficient mandate, they can play a critical role in driving digital transformation on behalf of their clients.

There are several concepts presented in the theory that support the idea that companies should invest in digitalization within the construction industry. As stated by Tangkar and Arditi, 2000, the construction sector is approaching market maturity, while simultaneously facing persistent productivity challenges (Hermansson & Song, 2024). Technical solutions, such as CDEs, may offer companies a means to address these issues effectively. If a company can develop new services or innovative business models using digital solutions as a foundation, it may gain a competitive advantage. The company where Expert 2a and 2b are active serves as an example of this approach. Their business model is based on technological advancement, enabling a fully digital workflow through the use of CDEs and other digital tools within their Construction Project Management practices. This approach has earned the company recognition and awards. According to the interview, they no longer need to explain their working methods to clients, as they can instead refer to their successful track record in delivering projects on time and within budget. This demonstrates that if a company can offer Total BIM solutions, it can create favorable conditions for market growth.

5.6 Challenges for Implementation of Digital Solutions

Implementing digital solutions involve various challenges. A lack of knowledge and a hesitant attitude are commonly noted factors. Addressing these aspects can support the effective use and potential benefits of digital solutions.

5.6.1 Ownership and Licenses

Access and ownership issues to CDEs represent a barrier for implementation. In some cases, consultants or contractors hold the licenses for the platforms where the models are managed, meaning the building owner may not have independent or long-term access to the model. As highlighted by expert 4a in the interviews, ownership of the model should lie with the client from the design stage to avoid fragmented information flows and loss of control. The challenges with licenses is also worsen by the fact that project organizations use a variety of different digital platforms and tools. Licenses for digital tools and CDEs is a cost and the question about who should pay for the licenses, and thereby own the digital model, should be held at an early stage of a project. This reasoning is strengthen by the theory about the fragmented nature as a challenge to digitalization.

5.6.2 Data Security

We have chosen to highlight this issue, as informal conversations with construction and project managers outside of the recorded interviews indicate that data security is a growing concern in the industry, and stakeholders perceive it as a potential barrier to the use of digital tool, particularly in security-classified projects. Data security is highlighted by Demirkesen and Tezel, 2021 as an important aspect that stakeholders in construction projects should pay attention to. Theoretical findings by Demirkesen and Tezel, 2021 also indicate that cybersecurity is often not sufficiently addressed within CPM. Several interviewees noted the risk that documents and information can be accessed by the wrong individuals when using CDEs, an issue they identified as a disadvantage. To prevent this, it is possible to set access restrictions within CDEs to control who can view specific materials. However, data security was not mentioned in the interviews in a more developed or strategic context, as emphasized in the literature. For example, the risk of cyberattacks or unauthorized access to sensitive information was not mentioned by either construction project managers, clients or experts.

5.6.3 Contract Limitations

Interviews highlighted limitations in current contract practices. Many projects still use design-build contracts, which make it harder to influence contractors' working methods. Experts with experience from digitally mature projects pointed to multiple-prime contracts as more effective, as they offer greater control over digital coordination. They also emphasized that contractual adaptations are necessary to ensure that all stakeholders commit to working digitally, without such requirements, interviews describe how traditional methods with 2D drawings often are used instead.

5.6.4 Market Challenges

Our study indicates that the development and availability of digital tools in the construction industry are largely driven by a technology push from providers of digital solution. Platforms offer extensive functionality, yet many of their features remain underutilized in practice. This highlights a gap between what the technology offers and how it is applied on-site. To bridge this gap, a stronger market pull from the users is needed, and the demand and initiative must come from the clients. However, as illustrated by Tangkar and Arditi, 2000, clients often lack the necessary knowledge and experience to actively drive digital adoption. While some clients recognize the potential and express clear benefits from using digital tools, neither clients nor construction project managers expressed a strong demand for digital solutions in the interviews, reinforcing the observation that the market pull is currently weak. According to theory, widespread adoption of new technologies typically requires a balance between technology push and market pull. In this context, the lack of pull from clients becomes a key challenge. For digital tools to be more widely and effectively implemented, clients must become more aware, not only of the potential benefits these tools offer but also of the processes involved in using them.

6
Conclusion

This chapter provides a summary of our findings, structured around the research questions in the study. In addition, it presents suggestions for future research, highlighting areas where further investigation could contribute to a deeper understanding of digitalization in construction project management.

How can client value increase during the construction phase by using digital solutions in the construction project management team?

- CDEs support open and centralized communication, which helps build trust between the client, contractor, and construction project manager. By gathering all information in one place, CDEs reduces the burden on the clients work and help them take more informative decisions. Better communication flows also lead to more efficient communication between stakeholders which prevents errors based on misunderstandings.

- Combining CDEs with status codes on objects leads to simpler and more accurate tracking of construction progress, reducing the risk of unexpected or growing delays. Early detection of delays allows for quicker action, helping to keep the overall project on schedule.

- A value for the client is fewer construction errors, which leads to reduced time and cost overruns. This is achieved by producing a correct and detailed BIM model early in the project, allowing errors to be identified and resolved before construction begins. As a result, fewer change orders are needed during the construction phase.

- Having a BIM model that includes all information from the design and construction phases, ensures that the As-built documentation truly shows what has been built. This helps create a digital twin, which makes facility management easier and more efficient. It also supports reusing materials when the building is eventually demolished, providing long-term benefits for the client in terms of both better operations and sustainability.

How can construction project managers utilize the function of digital tools in the construction phase?

- Site meeting minutes can be documented directly in the CDE, allowing issues and questions to be linked to specific people or groups within the project.

- 360-degree cameras can monitor construction progress, providing visual records that can be referenced in case of disputes or uncertainties. Construction project managers can also use these cameras to compare the real-world site with the 3D model.

- Construction project managers can extract reports from the BIM model within the CDE to communicate effectively with project stakeholders, showing the exact location and reduce the risk of miscommunication.

- RFIs can be managed within the CDE to keep track of questions and responses throughout the project life cycle. RFIs are also saved and can be tracked back in time.

- In the CDE, issues can be tracked systematically throughout the project life cycle. Updates, changes, and decisions are linked to specific times, individuals, and locations for clear traceability.

- During site visits pictures and issues can be uploaded and linked to the BIM model directly, ensuring immediate documentation with an exact location.

- Status codes can help the construction project managers to monitor the project schedule and control contractor progress more efficiently.

- Construction project managers can use the CDE for quantity takeoffs.

- BIM models can be integrated with budget management tools that automatically update costs based on construction progress. CPMs can use these tools to monitor budgets, ensure accurate pricing, and enable more frequent invoicing.

The construction industry is not yet fully digitalized. To achieve a future digitalization, tools like CDEs must be widely adopted across the majority of construction projects. This widespread adoption would help address current challenges related to resistance or negative attitudes toward digital tools.

To fully realize the benefits of digitalization, the building process needs to be digitalized starting from the design phase, using a high-quality BIM model. Additionally, all project stakeholders must be actively involved in the CDE to maximize its value.

AI has potential to transform the construction sector, but it remains unclear how it can be effectively used to create real value. Currently, AI is used mainly in construction phase as a texting tool rather than as a practical tool.

A fully digitalized workflow could help close the efficiency gap highlighted in the introduction, where industries like manufacturing achieve higher efficiency by delivering better quality products at lower costs and in shorter construction times.

6.1 Future Research

Future research could look into the cybersecurity challenges when using CDEs in construction projects. This includes finding out what risks digital tools have, like data leaks, hacking, or other security problems. Research could also focus on ways to reduce these risks and keep information safe while still allowing all project members to share and work together. Learning how to keep CDEs both open and secure will be important for making construction more digital in the future.

Future research could explore other digital tools beyond CDEs, that can be used specifically during the construction phase of projects. This includes technologies such as AI, VR, AR, and robotics. These tools have the potential to improve efficiency, safety, and communication on site. Research could investigate how these technologies are currently being applied, what challenges exist for their implementation, and how they can best support construction project management. Focus areas could be to identify practical ways to integrate these digital solutions into daily workflows and improve project outcomes.

Future research could focus on the economic incentives for clients to invest in digital tools within construction project management. This could include studying the relationship between the cost of implementing tools and the financial benefits they bring, such as time savings, fewer errors, or improved coordination. Future research could also include calculations or case studies that compare investment costs with the economic value created during the construction phase. Although existing literature like Marnewick and Marnewick, 2022 and Walker, 2015 points to the value of including digital solutions in the construction industry, it would help show how the use of digital tools is financially worthwhile for clients in the long term.

Future research could explore how BIM models can be connected to time planning and cost control in construction projects. By linking the model to the schedule, project managers can better plan and follow up on progress. Connecting the model to budgeting can also help with more accurate cost estimates and financial tracking. Future research could study how these methods are used in practice, what challenges exist, and how they can support better decision-making and efficiency during the construction phase.

Bibliography

Agarwal, R., Chandrasekaran, S., & Sridhar, M. (2016). *Imagining construction's digital future*. Capital Projects and Infrastructure. https://www.mckinsey.com/~/media/mckinsey/business%20functions/operations/our%20insights/imagining%20constructions%20digital%20future/imagining-constructions-digital-future.pdf?shouldIndex=false

Aliakbarlou, S., Wilkinson, S., & Costello, S. B. (2017). Exploring construction client values and qualities: Are these two distinct concepts in construction studies? *Built Environment Project and Asset Management, 7*(3), 234–252. https://doi.org/10.1108/BEPAM-06-2016-0023

Aliakbarlou, S., Wilkinson, S., & Costello, S. B. (2018). Rethinking client value within construction contracting services. *International Journal of Managing Projects in Business, 11*(4), 1007–1025. https://doi.org/10.1108/IJMPB-07-2017-0076

Atkin, B., & Bildsten, L. (2017). A future for facility management. *Construction Innovation, 17*(2), 116–124. https://doi.org/10.1108/CI-11-2016-0059

Bell, J., & Waters, S. (2014). *Doing your research project: A guide for first-time researchers* (6th ed). McGraw-Hill Education.

Boverket. (2021, July 14). Olika skeden i byggandet. Retrieved May 28, 2025, from https://www.boverket.se/sv/PBL-kunskapsbanken/teman/ekosystemtjanster/metod_byggande/skeden/

Boverket. (2024a, October 4). Avtal i byggidéskedet. https://www.boverket.se/sv/energiguiden/energieffektivisera-flerbostadshus/energirenovera/byggide/avtal/

Boverket. (2024b). Entreprenadformer och kvalitet. Retrieved June 18, 2025, from https://www.boverket.se/sv/samhallsplanering/arkitektur-och-gestaltad-livsmiljo/arbetssatt/upphandling/entreprenadformer/

Borrmann, A., König, M., Koch, C., & Beetz, J. (Eds.). (2018). *Building information modeling: Technology foundations and industry practice*. Springer International Publishing. https://doi.org/10.1007/978-3-319-92862-3

Braun, V., & Clarke, V. (2023). Thematic analysis. In F. Maggino (Ed.), *Encyclopedia of quality of life and well-being research* (pp. 7187–7193). Springer International

Publishing. https://doi.org/10.1007/978-3-031-17299-1$_3$470

Carnebratt, N. (2025, January 28). Examensarbete frågor.

Demirkesen, S., & Tezel, A. (2021). Investigating major challenges for industry 4.0 adoption among construction companies. *Engineering, Construction and Architectural Management*. https://doi.org/10.1108/ECAM-12-2020-1059

Disney, O., Roupé, M., Johansson, M., & Domenico Leto, A. (2024). Embracing BIM in its totality: A total BIM case study. *Smart and Sustainable Built Environment, 13*(3), 512–531. https://doi.org/10.1108/SASBE-06-2022-0124

Disney, O., Roupé, M., Johansson, M., Ris, J., & Höglin, P. (2023). Total BIM on the construction site: A dynamic single source of information. *Journal of Information Technology in Construction, 28*, 519–538. https://doi.org/10.36680/j.itcon.2023.027

Dolla, T., Venkatachalam, S., & Kumar Delhi, V. S. (2024). Institutional shaping of CDE implementation in BIM-enabled AEC projects. *Journal of Information Technology in Construction, 29*, 826–849. https://doi.org/10.36680/j.itcon.2024.036

Gamil, Y., & Abdul Rahman, I. (2018). Identification of causes and effects of poor communication in construction industry: A theoretical review. *Emerging Science Journal, 1*(4). https://doi.org/10.28991/ijse-01121

Hasan, A., Shrestha, A., & Neeraj Jha, K. (2025). *Construction company management*. Routledge Taylor & Francis Group.

Hermansson, C., & Song. (2024, January). Produktiviteten i bygg- och anläggningssektorn orsaker, åtgärder och konsekvenser. Produktivitetskommissionen. https://www.sou.gov.se/contentassets/945da4932abe4182be0009989ce2cb19/forskningsrapport_produktiviteten-i-bygg--och-anlaggningssektorn--orsaker-atgarder-och-konsekvenser.pdf

Ismail, H., & Mohd Yusof, Z. (2016). Perceptions towards non-value-adding activities during the construction process (S. Kamaruzzaman, A. Ali, N. Azmi, & S. Chua, Eds.). *MATEC Web of Conferences, 66*, 00015. https://doi.org/10.1051/matecconf/20166600015

Johansson, M., & Roupé, M. (2024). Real-world applications of BIM and immersive VR in construction. *Automation in Construction, 158*, 105233. https://doi.org/10.1016/j.autcon.2023.105233

Kärkkäinen, M., & Yledahl, A. (2025, March 31). Intervju examensarbete- digitala verktyg.

Knoth, K., Fufa, S. M., & Seilskjær, E. (2022). Barriers, success factors, and perspectives for the reuse of construction products in norway. *Journal of Cleaner Production, 337*, 130494. https://doi.org/10.1016/j.jclepro.2022.130494

Lindahl, G., & Ryd, N. (2007). Clients' goals and the construction project management process (T. I. Haugen, Ed.). *Facilities, 25*(3), 147–156. https://doi.org/10.1108/02632770710729737

Lindholm, J., Johansson, P., & Yitmen, I. (2025). Toward a BIM information delivery framework based on common data environment. *Construction Innovation, 25*(7), 139–157. https://doi.org/10.1108/CI-06-2024-0185

Liu, R., & Charmaine Chua, V. (2016). Theoretical digitalization of information flow in the construction supply chain. *International Journal of Management Research and Business Strategy*. Retrieved May 27, 2025, from https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=5f2db8873298d40061fe58e118cdc68a1d020

Marnewick, C., & Marnewick, A. L. (2022). Digitalization of project management: Opportunities in research and practice. *Project Leadership and Society, 3*, 100061. https://doi.org/10.1016/j.plas.2022.100061

Mikhridinova, N., Ngereja, B. J., Pinilla, L. S., Neumann, D., Wolff, C., & Van Petegem, W. (2023). Competences and the digital transformation: Case study of a german management consultancy. 2023 IEEE European Technology and Engineering Management Summit (E-TEMS), 168–171. https://doi.org/10.1109/E-TEMS57541.2023.10424045

Nie, X. (2024). Research on building quality optimization software based on building information model. 2024 International Conference on Telecommunications and Power Electronics (TELEPE), 391–395. https://doi.org/10.1109/TELEPE64216.2024.00076

Obododike Ekwuno, A. (2022). The value of effective communication in the construction industy. *International Research Journal of Engineering and Technology*.

Oke, A. E., & Aigbavboa, C. O. (2017). *Sustainable value management for construction projects*. Springer International Publishing. https://doi.org/10.1007/978-3-319-54151-8

Parn, E. A., & Edwards, D. (2019). Cyber threats confronting the digital built environment: Common data environment vulnerabilities and block chain deterrence. *Engineering, Construction and Architectural Management, 26*(2), 245–266. https://doi.org/10.1108/ECAM-03-2018-0101

Project Management Institute. (2021). *The standard for project management and a guide to the project management body of knowledge (PMBOK® guide)* (Seventh edition).

Sanchez, B., Rausch, C., Haas, C., & Hartmann, T. (2021). A framework for BIM-based disassembly models to support reuse of building components. *Resources, Conservation and Recycling, 175*, 105825. https://doi.org/10.1016/j.resconrec.2021.105825

Sears, S. K. (2015). *Construction project management* (1st ed). John Wiley & Sons, Incorporated.

Shoushtari, F., Daghighi, A., & Ghafourian, E. (2024, March 22). Application of artificial intelligence in project management. Retrieved June 11, 2025, from https://www.researchgate.net/profile/Ali-Daghighi/publication/385943436_Application_of_Artificial_Intelligence_in_Project_Management/links/673d0c4fb94c451c11667c7d/Application-of-Artificial-Intelligence-in-Project-Management.pdf

Sjöstedt, K. (2025, February 17). Intervju examensarbete- digitala verktyg.

Spencer, G. (n.d.). Getting started with autodesk construction cloud. Retrieved May 28, 2025, from https://static.au-uw2-prd.autodesk.com/Class_Presentation_CS501002_ClassPresentation-CS501002-Spencer-AU-2022.pdf

StreamBIM. (n.d.-a). Features. Retrieved February 13, 2025, from https://streambim.com/html/en/Features/About_StreamBIM.html

StreamBIM. (n.d.-b). Takt-planning. Retrieved May 2, 2025, from https://streambim.com/html/en/Features/Takt.html

StreamBIM. (n.d.-c). The advantages of storing data on a swedish server solution with StreamBIM for swedish construction industry stakeholders. Retrieved May 2, 2025, from https://streambim.com/html/en/Solutions/Security/Swedish_server.html

Taboada, I., Daneshpajouh, A., Toledo, N., & De Vass, T. (2023). Artificial intelligence enabled project management: A systematic literature review. *Applied Sciences, 13*(8), 5014. https://doi.org/10.3390/app13085014

Tangkar, M., & Arditi, D. (2000). Innovation in the construction industry. Illinois Institute of Technology, Department of Civil and Architectural Engineering, 2, 96–103. https://ced.petra.ac.id/index.php/civ/article/view/15527/15519

Udokwu, C., Norta, A., & Wenna, C. (2021). Designing a collaborative construction-project platform on blockchain technology for transparency, traceability, and information symmetry. 2021 2nd Asia Service Sciences and Software Engineering Conference, 1–9. https://doi.org/10.1145/3456126.3456134

Walker, A. (2015). *Project management in construction* (6th ed.). John Wiley & Sons Inc.

WSP. (n.d.). Byggledning. Retrieved May 20, 2025, from https://www.wsp.com/sv-se/tjanster/byggledning-och-installationsledning

A

Appendix A

A.1 Questions for Construction Project Managers

A.1.1 Background and Role

- What is your background? What roles have you held in your career?
- Which clients are you working with currently, and what is your role in those projects?

A.1.2 Work Methods and Tools

- How do you work today? What is analog, and what is digital? What tasks are recurring?
- When and how would you say problems arise in your role as a construction manager? What kind of problems?

A.1.3 Communication and Collaboration

- How do you communicate with contractors and clients in your projects?
- Do you use any digital tools to share or mediate information?

A.1.4 Construction Meetings

- What is typically discussed in construction meetings? What is *not* decided there?
- What happens if someone misses a construction meeting?
- How is information and decisions communicated during the 3–4 weeks between construction meetings?

A.1.5 Workflow and Scheduling

- Can it happen that a task is delayed because all relevant parties can't be gathered to discuss an issue?
- How do you ensure the project stays on schedule?
- What do you do during site visits?

A.1.6 Digital Requirements and Use

- Are there any client requirements regarding digital workflows in the projects you work on today?
- Do property managers ever reach out to you as a construction manager with questions?

A.1.7 Digital Tools and Their Impact

How (at what stages and to what extent) do you use digital tools, and how has that helped your work?

- Did the client use digital tools during the production phase? Was it their initiative?
- Who was responsible for the model? Was there someone knowledgeable to ask when issues arose?
- What was the outcome of using digital tools compared to a more traditional, analog approach?
- What happened to the model after the project ended?

A.1.8 Opportunities and Reflections

- Do you see any processes that could be further digitized?
- What are the benefits of digitizing construction management from your perspective?
- What do you feel is missing, or what prevents you from working more digitally today?

B

Appendix B

B.1 Questions for Clients

B.1.1 Background and Role

- What is your background? What roles have you held in your career?
- What is your role as a client?

B.1.2 Project Success and Decision-Making

- Can you mention some factors that contribute to a successful construction project? (Finishing on time and within budget, but is there more to it?)
- To what extent do financial constraints drive decision-making?
- What are you willing to compromise on?
- What would be justifiable reasons to exceed the budget?
- How involved are you during the construction process?
- How do you receive updates on the project's progress?

B.1.3 Project Monitoring

- Do you see any issues with current communication methods?
- How is the collaboration with construction managers and contractors?
- How can WSP's construction managers influence whether a project is successful or not?
- What qualities do you value when selecting a construction manager?

B.1.4 Digitalization in Your Organization

- How do you, as a client, currently work with digital tools?
- Programs/project portals for facility management and tools used during the project phase.
- What kind of digital tools or services would you like to have? (Both during construction and in the operational phase.)
- Do you have an in-house BIM expert?
- Do you own the 3D models used during the design (and construction) phase?

B.1.5 Handover and Information Management

- What kind of information do you request at the handover of the property?
- What do you actually receive? Is there a gap?
- How do you store technical building information (e.g., drawings)?
- Do you have digital twins of your buildings?
- Do you see value in having a digital 3D model of your properties? What kind of value?

B.1.6 Access to Project Information

- Is there information that you, as a client, lack access to that WSP's construction managers may have?
- Are you able to follow up on project schedules during the production phase to track progress?

C

Appendix C

C.1 Questions for Experts

C.1.1 Introduction

- Could you please introduce yourself and tell us about your role?

C.1.2 BIM Implementation

- How should one go about implementing BIM during the construction phase?
- What are the advantages of building completely without drawings?
- How should a drawing-free construction process be structured?

C.1.3 Role of Construction Project Managers

- How can consultants representing the client (such as construction managers) promote digitalization?
- In what ways could digital tools change how construction managers work today?
- Which processes can be simplified and how?

C.1.4 Digital Tools during Construction

- Which digital tools are best to use on the construction site and during construction?
- Could you describe the workflows for tools like StreamBIM, Dalux, and ACC?
- Are there any other digital tools currently used during construction, and what value do they create?

C.1.5 Digital Models and Data Ownership

- Who owns the digital model?
- Whose responsibility is it to "fix" or maintain the digital tool?

C.1.6 Value and Impact for Clients

- What value do digital tools provide to the client during the construction phase?

- Are there tools within Common Data Environments (CDEs) that could be useful for clients and construction managers?

DEPARTMENT OF SOME SUBJECT OR TECHNOLOGY
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden
www.chalmers.se

CHALMERS
UNIVERSITY OF TECHNOLOGY