Digitalization and model-based construction in Sweden

Evaluating competitiveness within the consultant industry

Master's thesis in Design and Construction Project Management

LUDVIG OOM

DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING

CHALMERS UNIVERSITY OF TECHNOLOGY
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MASTER'S THESIS ACEX30

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Department of Architecture and Civil Engineering
Division of Construction Management and Engineering
Examiner: Mathias Gustafsson
Supervisor: Mathias Gustafsson
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Department of Architecture and Civil Engineering
Division of Construction Management and Engineering
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone: + 46 (0)31-772 1000

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ABSTRACT

The construction industry face challenges with innovation and efficiency compared to other industries. The Swedish need of construction of both infrastructure and housing in the near future is high. Building Information Modelling (BIM) has been rising over the past decades, where modular-based construction is the core concept to increase productivity for the different construction phases. BIM work as informative hub where components in the construction contains necessary information instead of only a visual model. Collaboration can increase, design-phase decision can be made with precision and facility management can be performed with better efficiency. This is one of the areas where digitalization affects the whole industry and something the stakeholders can benefit from. Creating a city or environment where construction is made with higher productivity can impact various parameters such as environmental impacts, costs for inhabitants and lower service-related costs.

The aim of the thesis is to evaluate the incentives clients and facility owners have to order a digital project delivery with BIM, instead of traditional project deliveries. Further, the consultant perspective is taken to investigate how consultant companies can work with knowledge management and how their organization to position themselves for future opportunities within digitalization. The method information has been gathered is abductive and combines a questionnaire with semi-structured interviews with experts and leaders in the Architecture, Engineering and Construction (AEC) industry.

Summarized, the thesis demonstrates benefits of BIM from various perspectives, with provided incentives for its implementation. Increasing collaboration with cost-efficient solutions give competitive advantages for many different stakeholders within the sector. Lastly, recommendations are made for the different stakeholders such as clients and consultant companies with the purpose to lead the change of digitalization and BIM implementation within the construction sector.

Key words: BIM, model-based construction, total BIM, digitalization in construction, innovation construction, organizational knowledge management, increased competitiveness, digital project delivery.

Digitalisering och modellbaserat byggande i Sverige

Undersöker konkurrenskraft inom konsultbranschen

Examensarbete inom mastersprogrammet Design and Construction Project Management

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Institutionen för arkitektur och samhällsbyggnadsteknik
Avdelningen för Construction Management
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SAMMANFATTNING

Byggbranschen står inför utmaningar vad gäller innovation och effektivitet jämfört med andra branscher. Det svenska behovet av byggnation, både av infrastruktur och bostäder, är stort inom en snar framtid. Building Information Modeling (BIM) har ökat under de senaste decennierna, där modulbaserat byggande är ett kärnan för att öka produktiviteten i de olika byggfaserna. BIM fungerar som en informationshubb där komponenter i byggnationen innehåller nödvändig information istället för att enbart utgöra en visuell modell. Processens samarbete kan öka, beslut i designfasen kan fattas med precision och förvaltning av fastigheter kan ske mer effektivt. Detta är ett av de områden där digitalisering påverkar hela branschen och något som intressenter kan dra nytta av. Att skapa en stad eller miljö där byggnation sker med högre produktivitet kan påverka flera parametrar såsom miljöpåverkan, kostnader för invånare och lägre kostnader kopplat till service.

Syftet med examensarbetet är att utvärdera vilka incitament olika beställare och fastighetsägare har för att beställa en digital projektleverans med BIM, istället för traditionella projektleveranser. Vidare tas konsultperspektivet för att undersöka hur konsultföretag kan arbeta med kunskapshantering och hur deras organisation kan positionera sig för framtida möjligheter inom digitalisering. Metoden för informationsinsamling är abduktiv och kombinerar en enkät med semistrukturerade intervjuer med experter och ledare inom AEC-branschen.

Sammanfattningsvis påvisar examensarbetet fördelar med BIM ur olika perspektiv, med angivna incitament för dess implementering. Ökat samarbete med kostnadseffektiva lösningar ger konkurrensfördelar för många olika intressenter inom sektorn. Slutligen ges rekommendationer till olika intressenter såsom beställare och konsultföretag i syfte att leda förändringen mot digitalisering och BIM-implementering inom byggsektorn.

Nyckelord: BIM, modellbaserat byggande, Total BIM, digitalisering inom byggande, innovationsbyggande, organisatorisk kunskapshantering, ökad konkurrenskraft, digital projektleverans.

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Gothenburg. June 2025.
Ludvig Oom

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1. Introduction

Building Information Modelling (BIM) used in the construction industry presents both great potential and challenges. Digitalization in the modern world is moving forward, and the systems develop constantly. This chapter will give a brief background to the report along with limitations and research questions.

1.1 Background

The building sector stands for a rapid change. Environmental issues, energy consumption and increasing housing prices are among many others issues important to address (Fink, H. S. 2011). Worldwide, the building sector stands for 30% of Greenhouse Gas Emissions and 40% of energy consumption (Fink, 2011). Decision making during the design phase is important to align to the impacts both related to costs and environmental issues later in the process (Z. Liu et al., 2015). Covered areas in which decisions can be taken during the design phase relates to waste minimalization, material choices and alternatives lowering transportation emissions.

Economic conditions, infrastructure and population is essential for calculating the need of construction. Boverket (2024a) predict construction of housing to turn around and increase during 2025 followed by the economic situation for the past years. The Swedish central bank has decreased the interest during 2024, which give incentive for construction and better market conditions for customers. High costs of construction have led to a tough market for companies and their customers. Both companies and household's flourishes when the economic stability increases. The amount of completed housing was during 2023 at its peak in Sweden just under 70 000. The forecast shows a significant change for the year of 2025 where it is expected to be around 33 000 completed housing.

In another report, Boverket (2024b) emphasizes that the amount of housing in Sweden for the period between 2024 and 2033 is estimated to be around 523 000 new housing to have a balanced housing market. However, the estimation is 77 000 households lower than the calculation made three years ago. The reasoning behind this is a lower rate of population growth together with the high completion of housing over the past years.

Digitalization is constantly developed in many different sectors around the world. Doan et al. (2019) describes a concept called BIM which has rapidly been developed for the AEC industry during the past decade. The concept is about digital drawings instead of traditional drawings in 2D. Utilization can be made during all stages for the project, but it is necessary with correct design. Power plants, infrastructure and buildings are examples of projects where BIM can be implemented. The model is both used for visualization purposes but contains more than just an architectural 3D-model. It contains detailed information about the model and different elements. Insulation values, density and lengths are examples of information the BIM model contains.

Bryde et al. (2013) explains how project management focuses on parameters such as coordination, quality, time, cost and communication which is enabled by BIM. The most significant parameter is the economic gains. Harder to measure is the increase in collaboration and communication with the help of the digital model especially when

related to initial investments. Software training for project employees and licenses are examples on those initial investments.

A described unique nature of the AEC industry creates complex working environments (Dolenc, 2023). Paper-based and traditional 2D documentation leads to manual coordination which has not worked sufficiently and satisfactory. A need of innovative ideas, technology and digital solutions has shown to be widely recognized by stakeholders within the construction industry. Ways to improve efficiency and collaboration while still delivering successful projects is an approach the stakeholders have, searching for tools and opportunities to do so. The goal is to drag the industry more towards manufacturing where efficiency would lower construction costs, leaving room for improvements in other sustainable areas such as constructing more environmentally friendly or increasing affordable housing, which all are areas where BIM can contribute (Al-Ashmori et al., 2020).

1.2 Aim

The report aims to find BIM-related solutions which can increase the knowledge with digital solutions for clients operating in the construction industry and be adapted into a consultant company's organization. The aim is to focus on knowledge raising within the project organization when it comes to BIM especially in Sweden. Providing clear incentives for clients to start thinking about digital solutions, and transition from ordinary 2D-drawings to model-based is a part of the thesis. Mapping how BIM has been developed over the past years and how the tool is used today is necessary to understand and develop the potential with digital transformation.

A part of the target is to find the path a consultant company should take when it comes to digital solutions within project management, to ultimately gain a competitive advantage and develop the business area. The background itself does not provide an ultimate answer for the future. However, thoughts from project managers, BIM Coordinators, clients and pilot projects with different angles helps to reach an understanding and answer the research questions which relates to the aim.

1.3 Research questions

The research question has been developed to reach the aim of the thesis. Finding incentives for clients to start using digital solutions in the construction industry relates to the first research question. The second question relates to how consultant companies can work to gain a competitive advantage.

Question 1: *What incentives are there for clients to order services related to digital solutions in the construction industry?*

Question 2: *In which way can a consultant company use digital solutions to gain a competitive advantage within construction project management and how can knowledge transfer utilize this?*

1.4 Limitations

The aim of the report is balanced with limitations with the purpose to focus on the same questions during the process. Even if there is interest for further research, the thesis is bound to be performed within five months during the spring of 2025. Digitalization of the construction industry is developed in the whole world. However, the thesis aims to the Swedish construction and consultancy sector. Focusing on the Swedish sector is although enabled by literature and results from other countries as well, such as Norwegian cases and global studies.

Even though the legal framework can shift from different countries in the literature, lessons can be drawn in what works well abroad. The thesis is performed with a perspective of consultants and the organization on how to minimize mistakes. Gains from all phases of a constructions project are taken into consideration to understand digital solutions and BIM in a complete perspective.

1.5 Context of the Study – Norconsult

This thesis is written with the consultant company Norconsult as a case, but more specifically the Swedish department for Project- & Construction management West. Norconsult ASA is company listed publicly originally from Norway (Norconsult, 2024). The company provides services related to architecture, engineering and digital expertise to both public and private clients. Over 6000 employees are spread over 140 offices in Norway, Denmark, Iceland, Poland, Finland and Sweden. Local presence is combined with interdisciplinary knowledge. The business model clearly states that the most important asset the company has is the employees. Motivation, attraction and development is vital and the major resource Norconsult contains (Norconsult, 2024). Also, the CEO states in the same report that Norconsult aims to be a top three industry employer in the Nordics.

The Swedish side has around 1400 employees and the head office in Gothenburg (Norconsult, 2024). The divisions Buildings & Architecture, Infrastructure and Energy & Industry makes Norconsult cover a lot of areas within Swedish development. As a part of the division Buildings & Architecture – Project- & Construction management is the spider in the net for various construction projects. On the given department, project- & construction managers focus on helping the clients lead construction projects.

Digital technology is an area the company focus on (Norconsult, 2024). Together with sustainability, technology and innovation, Norconsults ambition is to grow on the Nordic market. The company has various offers to its customers during the entire lifecycle of projects just like competitors within the industry.

2. Theoretical framework

The theoretical framework is divided into three areas with different focus. Firstly, the construction sector is described in general setting the tone for what to be developed. Secondly, Building Information Modelling is covered regarding both implementation but also barriers. Thirdly, the chapter report how competitive advantage within the AEC industry works also providing a basis for an implementation of BIM to gain the competitive advantage.

2.1 Construction Sector

This chapter provides theoretical framework about the construction sector in general. Success factors, digital transformation and uniqueness of the sector is highlighted.

2.1.1 Success factors and KPI:s for construction projects

The AEC industry plays a crucial role for the development of any country, and Sweden is not excluded (Takim & Akintoye, 2002). Physical infrastructure including buildings, roads, railways and bridges can progress and grow the economy for a country. Clients, consultancy companies, facility owners, transportation companies and other stakeholders develop the construction projects together. Independent on sector, or if the project is on a private or public level, all stakeholders aim to be successful. Organizational capabilities, the financial situation, managerial works and technical solutions are all aspects which work as success factors in construction projects. A map how Takim & Akintoye (2002) present how success factors can be categorized and seen in Figure 2.1. The landscape outside of the project also plays a role with stability of economic and political situation together with business environment.

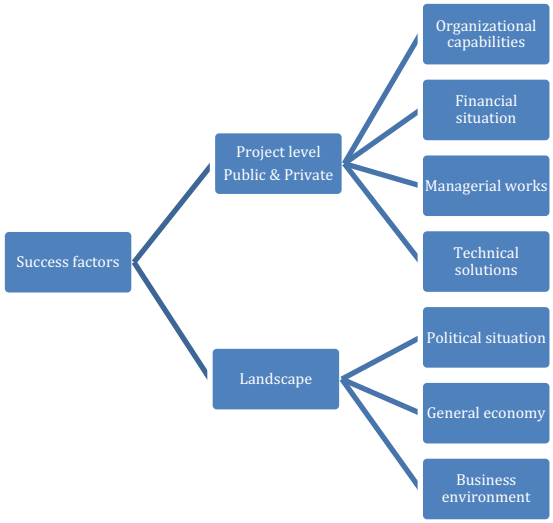

Figure 2.1: *Success factors for construction projects categorized. Modified from Takim & Akintoye (2002).*

Takim & Akintoye (2002) conclude that benchmarking and evaluation the success factor for a construction project is difficult. Different projects have different criteria which is evaluated. Key performance indicators (KPIs) can be benchmarked between projects, but since all projects differ in size and scale, it is hard to compare. The fact that the different construction projects does not use the same success factors

complicates the evaluation. A rebuild of a hospital would have different factors compared to a newly built apartment building. In most cases and projects, some criteria are fully met but not others. Stating the success for different parts of the construction is easier. Numerous key performance indicators show the success factor for different stakeholders during the different stages of the construction development process. For instance, the client can arrange and measure KPIs during the procurement stage regarding their social obligations, effectiveness in decision-making, contractual arrangements and project viability. The project- and out phasing can also be benchmarked with indexes in management structure, quality of work life, time and budget. Other criteria which can be measured for stakeholders such as consultants, supplier, contractors and community is exemplified in Table 2.1.

Table 2.1: *Examples of KPIs for the three phases of construction projects. Modified from Takim & Akintoye (2002).*

	Client	**Consultant**	**Contractor**	**Supplier**	**End-User**	**Community**
Procurement	Briefing process	Commitment	Performance	Value of replacement	Joint evaluation	Demands
Project phase	Conflicts	Coordination	Efficiency	Coordination	Continuous participation	Environmental effect
Phasing-out phase	Control measures	Possible jobs in future	Market penetration	Commitment	Minimum cost (ownership)	Safety

2.1.2 Uniqueness of Architecture, Engineering & Construction industry

The AEC industry is special in many ways. One of them is the uniqueness of its projects, teams and processes (Dolenc, 2023). Varying site characteristics, location and constraints make the different projects unique. Project management and construction techniques must take the unique project into consideration, making standardization hard. The lack of standardization can be compared to the manufacturing industry which has a production constantly repeating. Buildings, infrastructure and bridges always have varying needs and designs. This fact leads to challenges for productivity in construction with lacking collaboration, coordination and a high level of complexity.

The processes could be described as phases during the construction. Procurement, planning, execution, monitoring and demolition are all processes for a construction. Multiple stakeholders must be involved, shifting between the different processes (Dolenc, 2023). An architect might not be needed for monitoring, suppliers might not be involved during the early stages and engineers work heavily during the design phase. Effective project management is important for all processes to follow along the construction and succeeding with the project delivery.

Unique teams are described as the third and last aspect differentiating the AEC industry by Dolenc (2023). Just like processes, this involves stakeholders. Responsibilities are divided between the different stakeholders depending on their specialty. Architects, contractors, engineers and clients work in multidisciplinary

teams to reach a successful project delivery. All stakeholders have different agendas and focus differently on issues. The different perspectives give room for conflicts, so communication and management are also important to consider when designing a team.

The uniqueness of the AEC sector is further analyzed by Bosch-Sijtsema et al. (2021) with an analysis of how the Swedish side works with eleven different digital technologies. The paper focus on BIM, AI, sensors, 3D-scanning, robots, virtual reality (VR), 3D-printing, drones, cloud computing, digital twins and self-driving vehicles portrayed in hype curves. Performed workshops showed different barriers and hinders for usage and implementation of the technologies. A major barrier finding was lack of competence, where 19% of the respondents mentioned that training of people to higher the competence was needed and in some cases introduction from different disciplines. Business models used in Sweden was also hindering implementation in a large scale for the technologies. Other hinders mentioned is need of communication, legal issues, data security and a short-term focus approach.

A survey was also conducted, where the expectations on Swedish investments was measured from people working within the AEC sector (Bosch-Sijtsema et al., 2021). The respondents' expectations were that BIM is the area to be invested to the most, followed by AI (including machine learning), 3D scanning, sensors, robots and digital twins shown in Figure 2.2.

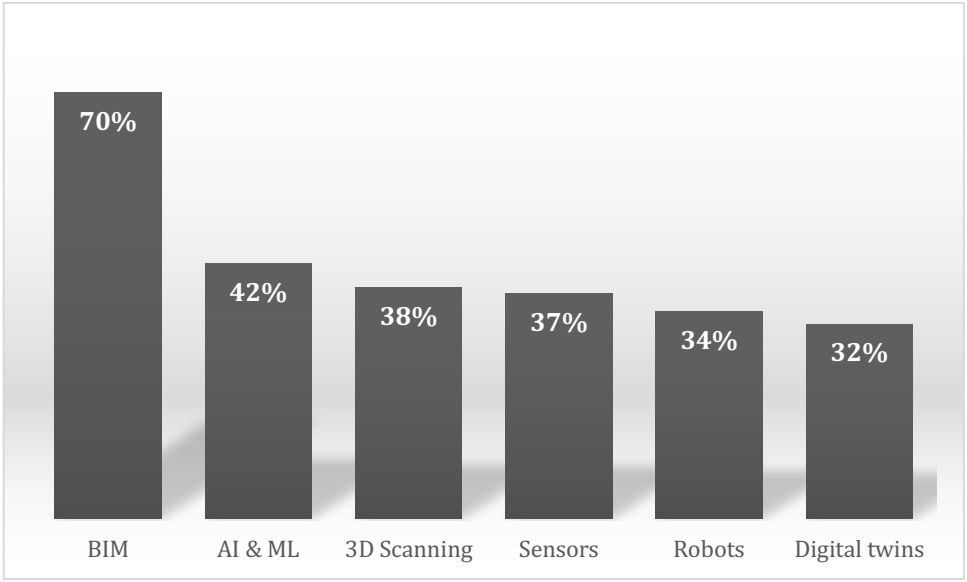

Figure 2.2: *Investments respondents expect the most in near future. Modified from Bosch-Sijtsema et al. (2021).*

Differences between different stakeholders was seen during the survey. Contractors, clients and lead designers all has different opinions (Bosch-Sijtsema et al., 2021). For instance, 79% of contractors and lead designers choose BIM but only 69% of the clients. Related to BIM, 60% of the respondents answered that they thought BIM would be fully implemented within a maximum of 5 years.

2.2 Building Information Modelling

Building Information Modelling is a major subject for both digitalization of buildings, but also the whole construction industry as a game changer. Universities, authorities and companies research and dig deeper into the benefits of BIM implementation. Awareness of benefits drawn from research and pilot projects can increase a construction projects efficiency, cost savings and productivity significantly (Al-Ashmori et al., 2020). Research shows how clash detections, time and construction cost decreases with a well implemented BIM coordination. Communication between different disciplines is an important factor to reduce those three success factors. The AEC industry is described to be slower than other engineering fields when it comes to efficiency (Cepa et al., 2023). Digitalization in general, and specifically BIM, is providing AEC a future for productivity.

BIM is model-based construction, which has evolved in a rapid pace for the past years (Doan et al., 2019). It is a digital model which is used in the design phase for real objects. BIM can be used for many objects such as buildings, bridges and power plants. The model does not only give a vision for a project, but also provides information about the different parts of the construction such as windows, concrete and insulation.

Using digital tools give advantages related to the model itself, lowering clashes and optimizing the objects performance during the whole lifetime. Designers realize and can correct mistakes and clashes in the early stages rather than adjusting later in the process (Kubba, 2012). Calculations and extractions of material and quantities in the model can easily be made since they build the 3D model and is not only a visualization with geometric structures (Ignatova et al., 2018). The digital model contains characteristics of the real object “as built” so all information needed is reliable to use as drawings and necessary calculations. Drawings themselves does not provide values, weights and other characteristics. Software using BIM is enabling extractions related to these values, weights and other parameters for the construction. Examples of different software which can be used is Tekla, Autodesk, Dalux etc. (Dolenc, 2023; Ignatova et al., 2018.). Tools and functions in the software differ but all remain the core concept of enabling model-based construction, working as both a 3D model and at the same time a collaborative working environment.

However, the potential is greater than model advantages and efficiency for the designers. Collaboration and utilizing digital transformation for project management plays a crucial role for productivity and cost efficiency (Bryde et al., 2013; Doan et al., 2019). Model based construction can act as a bridge between the different stakeholders and parties involved in a project such as clients, the main contractor and consultants. Designers visualize the construction for stakeholders in a higher grade with digital models, leading to higher involvement and a better understanding of the construction compared to original 2D-drawings (Kubba, 2012).

Scheduling, planning and collaboration are important factors for a construction to be performed on time and within the set budget (Takim & Akintoye, 2002). Cepa et al. (2023) describes how efficiency and productivity in the AEC is behind other engineering fields. The suggested solution is model-based construction. Scheduling, planning and collaboration can be performed in a more efficient way with systematic

approaches and a well utilized BIM model. Traditional scheduling does not involve BIM, and a common system used is the Critical Path Method (CPM) or Gantt charts (H. Liu et al., 2015). The critical path is what limits the progress of a construction relating to time. CPM is performed manually and seeks the critical path when there are many different disciplines operating on a construction simultaneously. Reducing the critical path ultimately reduce the total time. If time is reduced outside of the critical path, it does not affect the total time for the construction. Errors related to the human factor when designing a CPM is a fact leading to misleading results. Computer Aided Design (CAD) and BIM is developed to go from this manual 2D system to a better integrated and reliable scheduling.

Planning and scheduling must always take the critical path into consideration. An important aspect to consider is to identify conflicts even before they occur (H. Liu et al., 2015). A visualization of the construction will help with this, since it is easier for different disciplines and specialist to understand each other's needs and demands. Identifying conflicts even before they arise is not only limited to a person's former knowledge, but a construction sites visualization with 4D-CAD can be used. Following the progress of the project already during the design phase is a game-changer when it comes to planning and scheduling. The foundation to predict and decrease conflicts and clashes during the construction phase is a developed digital model, with characteristics in the construction parts used for information gathering and visualization. H. Liu et al. (2015) conclude that construction schedule with information from the digital model drastically can reduce the risks of human error and support site management.

Stakeholders in the AEC has historically been dependent on communication with two-dimensional models (Goh et al., 2014). Technologies such as CAD and BIM enable new ways of thinking, not only for designs and planning, but also for communication within projects. The potential with digitals tools regarding communication is high. Different stakeholders within a construction project can communicate on the platform in many ways such as commenting, taking pictures and reporting. Ultimately, the digital model can be a tool to coordinate the project.

Goh et al. (2014) remarks how communication and collaboration between the stakeholders reflect upon the cost, time and quality significantly. Poor communication is major factor for unsuccessful projects, and traditional methods lays the foundation for lack of collaboration. Relying on email conversations and phone calls leave room for human error. Azhar et al. (2012) describes how BIM is developing and replace CAD systems so communication must be planned accordingly. BIM models are digital and can be used in smartphones leading to fast responses and a rapid decision-making process independent on where the stakeholders are and during which phase the construction is in.

Other than reduced costs, increased quality, improved efficiency and collaboration, BIM potential are also linked to data reuse and automation (Sundquist et al., 2020). Automatic quantity take-offs and generation of other specifications can significantly increase the efficiency for many different stakeholders and disciplines.

2.2.1 BIM implementation

Professions change and develop over time since the technology around us develop. BIM implementation in AEC has developed in a rapid change for the past 25 years (Ghaffarianhoseini et al., 2017). During the period from early 2000s, technical advancements has severely increased the potential for implementing BIM in different projects and even though pilot projects have been performed with success BIM is not used to its full potential.

Implementation of BIM varies among the different parts of the world and Sampaio (2021) states that the digital transition is driven by competitiveness in the industry. Traditional 2D-drawings evolved to CAD, where designers increased their productivity with the digital tool. Next step is widely implementation of BIM. Compared to CAD with the geometrical structures, BIM involves all disciplines. Centralization of information gives both major advantages but also problems. Initial investments are necessary for implementation. The technology and software do not limit modular building, but regulations and people can be seen as barriers (Sampaio, 2021).

Several projects can work as pioneers when it comes to BIM implementation. The Swedish projects New Slussen in Stockholm and Celsius in Uppsala has been performed with a model-based construction and exemplifies how efficient digital solutions can be (Ulutas & Gustafsson, 2025). New Slussen was performed before Celsius, and because of the results two virtual design construction (VDC) managers from Slussen also formed the project in Uppsala. The digital project delivery during Celsius worked as a legally binding source, and even if this fact set a much higher standard for details early in the design process it led cost savings for the total budget.

Increasing the BIM related skill-level of people involved in a project enables the transformation (Sampaio, 2021; Ulutas & Gustafsson, 2025). Building as-usual was challenged in New Slussen especially for personnel on-site. Lacking digital knowledge was solved with integration between the designers and site-construction. An important aspect in the training of the personnel to rely on the model instead of 2D-drawings was transformation in small steps, slowly moving towards construction with digital tools compared to the option of a quick decision, demanding people to adjust from one day to another. The software itself was also challenging for implementation in New Slussen, since it was not initially designed for site usage. Technology and software have evolved over the years, becoming more user-friendly for all stakeholders in the industry.

Contractors and designer who did not want to apply the new system in Celsius were excluded from the project, leading to all parties involved in the project was eager to learn more and test the program together with the construction management company (Disney et al., 2024). Stakeholders within the project could open and access information on their own devices leading to time reduction for the on-site entrepreneurs. The completely model-based construction was further used, as two of the VDC managers from New Slussen also followed along to the construction of Celsius (Ulutas & Gustafsson, 2025). Those managers increased and embraced collaboration in both given projects with regular VDC meetings. The detailing in the model for Celsius was precise and not only used for collaboration between stakeholders, but also for measurements and ordering. A main target for the 3D model

was to work as a legally binding document which enabled this data extraction for measurements and ordering basis. This is called Total BIM (Disney et al., 2024).

Clear responsibilities and a defined information strategy from the beginning increase the efficiency. For instance, early contractor involvement in the design phase leads to less change orders later in the process and reduce delays. Training for the different stakeholders to use the digital tools is also crucial, especially for on-site personnel to understand the functions. The training is simplified by user-friendly software and leads to trust among the different stakeholders. However, the most important aspect to cover for successful implementation is to address problems together in a collaborative approach between the different stakeholders such as the client, the design team and on-site personnel.

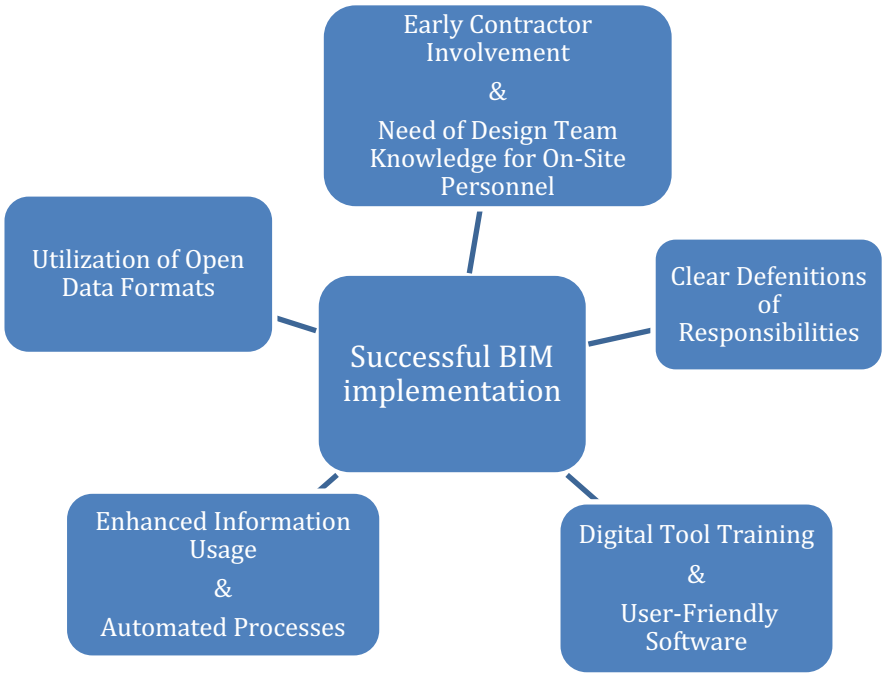

Figure 2.3: *Successful BIM implementation. Modified from Ulutas & Gustafsson (2025).*

BIM is seen as innovative in the AEC sector. An innovative mindset is required for a successful implementation, but there are uncertainties on if the innovation should be client- or supplier led (Lindblad & Guerrero, 2020). Disney et al. (2024) gives a clear understanding on how important the innovative mindset was for Celsius. The construction management company led the implementation of BIM in the project, with clear support from the client. Active participation and demands in the procurement regarding BIM technology by the client is called client-led innovation (Lindblad & Guerrero, 2020). On the other side, supplier-led innovation is competitiveness between suppliers to gain an advantage with improved and more efficient services and products.

Influential clients in the construction sector are crucial for development within many different areas. An active client demanding BIM implementation during the early stages, often the procurement, pushes the BIM workways forward (Lindblad & Guerrero, 2020). The client-led innovation also enables and creates the supplier-led innovations since suppliers compete for the same project. This could be seen in the

project Celsius, as designers and contractors not willing to adapt was not chosen during the procurement (Disney et al., 2024).

Disney et al. (2024) states that data ownership is important for implementation of BIM and an aspect to consider, which otherwise can work as a barrier. To fulfil its full potential of BIM adoption, delivering full ownership of the model to the client extends the usage (Olatunji, 2011). There are several areas to explore with the BIM model after the construction phase is completed. Facility management is one of those (Disney et al., 2024: Olatunji, 2011). Developing a digital twin requires the model, which later can be used for facility management. Designers and the construction management company's submission of the model to the client also enables the client to increase the efficiency in potential re-works, interventions in the construction and demolition. Demolition of constructions could potentially take place in hundreds of years, where 2D drawings could be significantly harder to understand than a modular-based digital drawing with all elements and information about them.

Project management focuses on cost, time, quality, coordination and communication. All areas where BIM is a tool to be used (Bryde et al., 2013). Cost impacts were the most significant according to the studies of Bryde et al. (2013), but the other aspects also had improvements because of BIM implementation. The iron triangle (cost, quality and time) is a core concept, but integration and coordination are vital especially for complex constructions with many involved disciplines. High initial costs cannot be overcome by just cheaper investments. Seeing the big picture is crucial. One of the initial costs is training in software knowledge for the project participants, something that will be paid off over time since employees get educated and bring on the knowledge to upcoming projects.

2.2.2 Challenges with BIM

Digitalization does not happen by itself over night. Hinders, barriers and challenges are also the case for adopting BIM in the construction sector. Sundquist et al. (2020) presents how gains and hinders for implementation has been shown over the years. Notable patterns emerge both for pros and cons. Poor model-quality and insufficient education has been challenging and could also be seen from the findings in Celsius and New Slussen (Ulutas & Gustafsson, 2025). Related to insufficient education is also the lack of on-site technical support (Sundquist et al., 2020). However, Ulutas & Gustafsson (2025) presented this as a factor for success in Celsius. The software itself is also discussed as crucial for projects, specifically when the software is described with lacking ease of use (Sundquist et al., 2020). Bryde et al. (2013) also emphasizes that soft- and hardware issues was the most challenging for the evaluated projects. Problems addressed with stakeholder involvement and training in the digital tools. Documented tendencies to use regular 2D solutions when projects are put under pressure is also slowing down adoption to digital 3D solutions and high initial costs of investment for BIM are another factor which is challenging a full-scale implementation, related to reduced project costs and increased efficiency. Cepa et al. (2023) further discusses how these initial investments are hindering implementation since it is time-consuming and in complex processes.

Lack of liability for cyber security is also an issue, and not only the ownership itself. Data thefts, hacking and viruses is problematic for all digital systems (Olatunji, 2011).

Cyber security issues are an aspect to overcome to guarantee full customer satisfaction, an issue much wider than just implementation of BIM, but for digital transformation in all sectors such as banking, journal management in healthcare and personal information on social media platforms. Hence, the AEC sector cannot oppose the problem alone to implement digital transformation. Laws and regulations both global and nationally must increase the possibility for cyber security but still leave room for digital transformation.

Another issue relating to digitalization is rights regarding the databases. Companies see their databases and models as own property (Smith, 2014). This is problematic and provides a clear competitive disadvantage for works to be done later in a construction's lifetime. Smith (2014) gives an example of cost data bases of different management consultants. This is a critical consideration specially related digital solutions – data ownership. Data ownership is not only important during the construction phase, but also when the construction is finished since the digital model has possibilities such as digital twins and efficient re-works. The legal liability can be uncertain since many different disciplines often work in a project with BIM, and important to solve in the early stages of a project.

Decisions about BIM together with associated costs are typically made in companies project levels, leading to a project implementation of BIM rather than an overall implementation for the company (Sundquist et al., 2020). Organizational implementation is enabled with communication of benefits with BIM to strategic important managers.

Another major issue is related to sectors limited to laws and other regulations hinders a complete digital transformation (Sundquist et al., 2020). BIM does not work as a legally binding document, which requires users and pioneers to also work with a 2D-model even if a complete BIM model is in place. Those problematics delay a full-scale implementation of BIM severely. Hence, investments will drag more to 2D-drawings which is the required way of documentation. Ultimately, our rules and laws make implementation on macro-level inconsistent. Standards and regulations for the AEC sector is what companies and authorities adapts to, independent on if it hinders digitalization. Legal responsibilities must be taken into consideration for all construction, since this cannot be solved by investments or other tools to overcome problems with construction.

2.2.3 Total BIM

Total BIM refers to an even higher ambition in the approach than original BIM. This is made by utilization of BIM in its totality as a sole source through the whole design and construction process and not only as a tool (Disney et al., 2024). The reliance of traditional 2D drawings is completely abandoned. In contrast, traditional BIM is supplemented using 2D solutions in processes where it is necessary. The work can lead to excess of information since its processed both in the 3D-models and 2D-drawings. The biggest risk of this might not only be extra work, but disconnections between the two models leading to various disadvantages.

Using Total BIM has several key components for successful projects. A single source where all stakeholders constantly work with the same model is important to lower the

risks of clashes and mistakes. The central hub minimizes the amount of communication, and updates in the model will be seen by everyone involved since one format is used. Paper drawings are not generated, and the digital workflow is easily accessible for also site workers and entrepreneurs.

Disney et al. (2024) also states that the approach with Total BIM involves the model to work as a legally binding document. An example of this is presented by both Disney et al. (2024) and Ulutas & Gustafsson (2025) with the project Celsius where the BIM model was accepted as legally binding source. IFC files can dictate the contractual aspects and are important for implementation of not only traditional BIM but also Total BIM. The primary contract document clearly states responsibilities and commitments and with Total BIM it is easy to track which stakeholder who fails or fall behind. Change orders can also be handled with the help of Total BIM, just because the model is contractual.

Enhanced collaboration is the overall advantage with Total BIM, just like traditional BIM. The difference is that Total BIM can force all project participants to integrate better to the digital world with all kinds of communication and collaboration. Disney et al. (2024) presents crucial factors to keep in mind when planning for Total BIM. The advantages are clear, but programs must be chosen carefully especially for the on-site personnel. The contractor's perception of digital workways is dependent on powerful and useful mobile BIM-viewers. Another success factor is the strong and clear management and leadership the construction management company can implement with Total BIM as a tool.

2.2.4 Digital twins

A potential outcome of BIM is digital twins (Mihai et al., 2022). Digital twins are described as a part of the fourth revolution with an accelerating digital transformation. A digital twin is a copy of an existing structure. It may be a bridge, power plant, building or city. The object is reporting the status to the digital twin in real time which give room for a numerous number of benefits. The twin can for instance simulate what will happen if actions and renovations are done in a cost-efficient way. Traffic situations on bridges, productivity in power plants or water flow in buildings are examples of simulations in the digital twin which increase the productivity and can work as a basis of decision-making.

Similarities of BIM and digital twins are many (Ignatova et al., 2018; Mihai et al., 2022). Ignatova et al. (2018) states that BIM is a developed CAD model, including more than just structures. The information within a BIM-model is what later can build a living construction in digital twins. The virtual twin differs from BIM since BIM is a model used in design- and construction phases. Digital twins are used after the project delivery. However, digital twins depend on exact information both from the construction and sensors updating the twin constantly. Digital twins are dynamic compared to BIM and is therefore similar to BIM but taken a step further.

Mihai et al. (2022) describes how different technologies drive the fourth industrial revolution. Constructing with the help of BIM lays the foundation for digital twins, but there are other technologies also driving the evolution. Machine learning and artificial intelligence enables predictive analysis. Virtual reality can increase

interaction for users of the digital twin. Giving real-time updates in the digital twin is enabled using different sensors. Upsides with digital twins are like the benefits with BIM. However, the digital twin does not focus on the construction part but instead more of maintenance, monitoring and reduction of emissions.

Enhanced monitoring and maintenance are a main area enabled with digital twins (Mihail et al., 2022). Condition and performance of the existing physical assets works proactive when it comes to maintenance. It may also prevent unexpected failures and solve problems early and directly when the occur instead. The decision-making working with objects which has a twin on the computer is improved by the opportunity to better simulate the decision to be made and the corresponding impacts. Similar to efficient decision-making is potential cost savings. Identifying outliers such as energy consumption can severely improve utilization of resources and decrease operational costs. Gathered information in the digital twin can serve as a platform for integration of other technologies as well, such as evaluations of the environmental impacts with emissions a construction has during the daily operations.

Barriers and hinders for implementation of digital twins are similar to the barriers with BIM (Mihail et al., 2022; Sundquist et al., 2020). Many different stakeholders are involved in these projects where the digital solutions are used, leading to problems regarding governance and data ownership. Expensive investments are also contributing as a hinder for implementation, since the return of interest (ROI) is not obvious for all stakeholders.

2.2.5 Digital transformation & Smart cities

Smart cities are described by Ignatova et al. (2018) to be a concept that includes environments which are safe, eco-friendly and comfortable for inhabitants and visitors. Forming a city and society which fulfils these parameters is based on information processing. Understanding how humans move and behave is crucial for planning a smart city. Digitalization and technology enable this. Usage areas for technology are both human movements, but also how we use our buildings. The goal when designing a smart city is reaching sustainability within the whole construction. Sustainability is divided into three areas – Social, Environmental & Economic.

Usage of buildings and other construction in a smart way enables sustainability and decision-making (Ignatova et al., 2018). The sources water, gas and electricity can be utilized better and improved with digital transformation in cities. Creating satisfying conditions with the sources is crucial for human comfortability. Digital transformation involves technologies which are advanced and integrated to enhance the operation of buildings, potentially lowering their footprint. Creating efficient and data-driven processes throughout the constructions lifecycle is emphasized by Ignatova et al. (2018) to be important for the industry.

Ignatova et al. (2018) shows clear possibility to go from traditional construction practices to more data-driven ones. This is something smart cities rely on to reach safe, eco-friendly and comfortable areas for us humans. Urban areas and countries differ, but the possibility for incorporating IT infrastructure and digital solutions is a fact and ready to implement. Concluded in the article Ignatova et al. (2018), is that the technologies are rapidly evolving and choosing the right method depends on each

project and construction. How companies involve the technology regarding digital transformation can and will reflect upon their efficiency and profitability.

2.2.6 Potential incentives for a client to order BIM

One of the gains for the client when ordering and working with digital solutions and BIM is facility management. Extraction and analysis of the building during the long operation-time give clear advantages related to facility management which otherwise can be problematic (Ignatova et al., 2018).

BIM enables advantages for the whole process, from early design phases to re-works and demolition 50-100 years from the construction. Clear incentives to order services related to BIM comes from productivity and cost-efficiency (Moreno et al., 2019). The client is placing the order most beneficial when it comes to time, costs, safety and sustainability. Owners in the public sector has also seen higher quality products and reduced costs during the life cycle when BIM is implemented. The digital way of working is enabling the other disciplines to work efficiently. Designers and contractors will be able to also work with the digital model and involve the client during both the design and construction phase.

Moreno et al. (2019) showed that most of the stakeholders within construction used BIM, primarily led by MEP-engineers (mechanical, electrical & plumbing), architects and structural engineers. Since the client is taking decisions during the process, understanding the decisions to be taken can for instance be visualized with BIM. Better decision making is crucial for the client and an incentive to consider when evaluating the use of BIM in a project.

Reduction of costs for construction projects will ultimately lower the costs for the client. With well implemented digital tools also the contractors can perform in a more efficient way, reducing costs and saving time during all stages of construction (Moreno et al., 2019). Cost-efficiency are important for the client. Controlling the budget with accurate cost estimations is also made with the information from the digital model. Miscommunication is also an aspect reduced with BIM and additional works with change orders can be influenced with a higher degree of communication.

When the construction phase is over, stakeholders such as contractors, designers and consultants leave. Clients remain with ownership over the construction so all the advantages from the BIM model is directly linked to the client. Lin et al. (2022) states that 3D illustration allows the owner to use benefits from the model in daily operations such as facility management. Energy analysis, tracking material and fulfilling the sustainability goals are examples of how the clients can use BIM in their facility management. Repairs is also an important thing to consider, and future costs is reduced with the correct digital models.

2.3 Organizational structure & Competitive advantage

This chapter provides theoretical framework about organizational structure and competitiveness. Gaining competitive advantage in construction, BIM implementation as a competitive factor and knowledge management is highlighted.

2.3.1 Competitive advantage in the construction sector

Leontie (2022) states that the construction sector drives the society and economies around. The harsh climate within the sector can be survived with highly competitive advantages. Management and organizational advantages are one of the aspects, and technical solutions and efficiency is another within the area. A driving factor is related to economy. Having the ability to cost less than competitors will give a clear upper hand in the procurement phase, since contracts and projects are won this way. Putting a lower price at your services compared to competitors is usually done by performing your activities in an efficient way reducing own costs.

Cost advantage together with differentiation is general competitive advantages (Leontie, 2022). Differentiation specifically can be made in four different categories:

1. Organization & Management
2. Financing
3. Technology & Innovation
4. Size of entity

Organization and management for example relate to safety culture, sustainability and alliances between companies (Leontie, 2022). Financing relates to investments and funding, and a possible investment relates to available resources which can be invested into new digital technologies. To gain an advantage with technology and innovation, productivity is a driving factor which reduces time and costs. The fourth and last category states that companies with different sizes have different advantages such as reputation and oligopoly.

Determining the strategy for a company operating in the construction industry is complex. The location and size of the company give openings for different strategies, which must be considered to evaluate and create an appropriate strategy (Leontie, 2022). Adoption of existing technology, even if it is sometimes obvious, can give advantage related to competitors. Organizational structures are the framework around which can both promote and limit digitalization, giving the opportunity to adopt the existing technology. Since the AEC industry in Europe is focusing on lowering the CO2-emissions and increasing the energy-efficiency in buildings, technology works as an enabler and a crucial ingredient for gaining a competitive advantage.

2.3.2 Implementing BIM as a competitive advantage

Companies investing in BIM position themselves favourably (Smith, 2014). Taking advantage of the wave with digitalization increase the competitiveness for most companies. Skill development and personnel training must be taken into consideration when implementing BIM as a competitive advantage, also emphasized in Ulutas & Gustafsson (2025). The industry involves heavy investments, but the profit margins are narrow (Smith, 2014). Long-term benefits with digital investments such as BIM can relate to differentiation within the area of size of entity. The ability to invest can be limited for companies which are small or have other financial issues, such as narrow profit margins. Macro-economics and recession also affect the decisions made. A large company or cooperation with stable economy does not directly lead to heavy investments with technology, since different cooperate regulations can limit new systems. On the other hand, small companies might adjust quick to gain the

competitive advantage directly also relating to the fourth category stated in Leontie (2022).

Innovative ideas and adoption of BIM is driven by industry leaders (Smith, 2024). Those leaders can operate in fields such as government, firms, public and private sectors within the AEC industry. The leaders shape the landscape of the industry, and work as pioneers for driving the industry forward. Decision makers enable other companies and businesses to follow and create an environment where all strive forward to gain the competitive advantage. Minimizing risks and reducing costs is a major factor decision makers evaluate when choosing between options. Success for construction businesses is described by Smith (2024) to depend on their adaption to the new digital landscape. Competitors seek opportunities to reduce their costs and minimizing risks, and adaption to the digital landscape is a factor which is highly related to this. The organization and management set the frames, and the digitalization can flourish in an environment filled with people with a mindset towards innovation and technology (Leontie, 2022).

Even though the AEC sector is characterized by an approach saying: “Wait and see”, Smith (2014) states that competitive advantage is a trigger for implementation of BIM in a larger scale. Minimizing risks and reducing costs is a factor, and a good way to evaluate an investment is the method where profit/return is related to the investment – Return On Investment (ROI). The core of a business is profitability, and decision makers will always take decision if there is a clear positive ROI. Communication regarding the ROI can work as a barrier if done poorly.

2.3.3 Managing knowledge in an organization

Knowledge and an efficient possibility to overcome obstacles is developing companies in many industries. Knowledge management can work as a tool to gain competitive advantages in several areas (Rowley, 1999). Transferring information and learning from each other is crucial for survival and something companies struggle with even today. Using accessible knowledge to make informed decisions will lead to more efficient processes. The risks when knowledge management does not work is that information is lost when people quit their jobs, and time consuming even in cases when there is a quick solution internally which cannot be found. Mistakes cannot be eliminated in all cases, but knowledge management can minimize costly mistake where a pattern can be seen, foreseeing actions and struggles before they occur with prior knowledge and lessons learned.

Depending on a single person for a successful project has a clear room for error and failure. The core concept of knowledge management minimizes this risk, since information is gathered, knowledge is embedded in the processes and growth is facilitated in the culture (Rowley, 1999). While many organizations recognize the value of managing their knowledge and have initiatives to improve processing, few organizations have fully adopted. Implementation of a full-scale knowledge management system reshaped the structure of the organization together with culture and responsibilities which both managers and employees have. This is a transformation and implementation which must be decided by senior leaders and top management, who must carefully evaluate critical questions.

Questions which could be related to which technologies and techniques to be used but also the central objective of why the organization should focus on knowledge management and in which roles. There might be a need of support both in the beginning and during the process so questions will occur on who should handle and support this aspect. One of the areas where knowledge management may be important is BIM. BIM possess great potential, but all stakeholders and employees not working directly with BIM have less knowledge about the advantages (Ulutas & Gustafsson, 2025).

Embracing and embedding knowledge management has a nature which is likely to always change depending on things such as technologies and which business area a company operates in (Rowley, 1999). Knowledge management provides a great opportunity for companies and organizations to accelerate their competitiveness on the market and is a vital ingredient for survival.

3. Methodology

A literature review has been conducted to explore how the industry operates today. A mixed sampling method was used combining both quantitative and qualitative research approaches. The empirics in the mixed sampling method came from both an internal questionnaire and interviews with different experts within the industry.

3.1 Research strategy

Research can be approached in three different ways: Deductive, inductive or abductive (Bell et al., 2022). Inductive reasoning takes observations and the generalise them to a conclusion. The suggestions are likely but not always entirely true. Deductive reasoning is the opposite. Generalisations are implemented for specific cases and concludes the specific case by the generalisation. Just like inductive reasoning, deductive reasoning is not always true. The third and last alternative has been used more frequently nowadays, abductive reasoning. During abductive reasoning, the best possible explanation is used. An observation give room for the explanation and even if there is a possibility for another explanation, the one which makes the most sense is used since the probability is high.

The approach method should be chosen according to the aims of the report. Abductive reasoning is described in Bell et al. (2022) to work well in interpretive research. This thesis is conducted with a mixed research approach, involving a qualitative analysis. Abductive reasoning works well with the qualitative part since empirics and theory has a dialogical process. Abduction can be seen as a combination of inductive and deductive reasoning, but it works in a way to overcome the limitations and risks with these approaches. With the abductive research this thesis starts with an observation with the need of digitalization within the AEC industry and tries to find the most simple and likely solution. Even though the abductive reasoning is not completely certain, it is probabilistic.

Research methods can be quantitative, qualitative or mixed (Bell et al., 2022). This thesis will sample information from both a questionnaire and semi-structured interviews. The questionnaire is sampling of information and data in a quantitative way. However, interviews are a qualitative analysis where strict numbers cannot be seen. Combing these two makes the research method used in this thesis mixed.

The abductive approach enables combination of literature study and empirical information gathering during the same time and adjusting to the necessary literature depending on the findings from the empirics. Information is therefore studied simultaneously. The study consists of different parts and phases during the spring year 2025 presented in Figure 3.1.

The first part consists of problem formulation, evaluating which problem in need of development. Formulation of the problem will later lead to finding research questions fitted to the addressed problem. A major part of the report is the literature analysis, which is performed after the addressed research questions, a part which follow the report and is updated until the end. The empirics starts with a questionnaire study, providing a base for how employees at the company see the problem. The base is then developed with semi-structured interviews both internal and external. Results and

discussion are based on both the literature study and empirics which later become conclusions and suggestions to stakeholders within the industry.

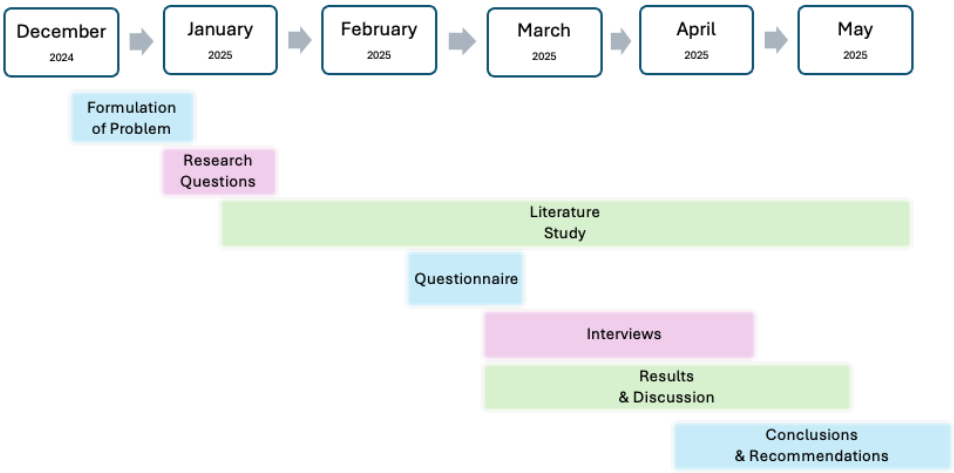

Figure 3.1: *Schedule for the thesis with different phases.*

3.2 Literature study

The first phase of the thesis consisted of analysing literature regarding the subject to gain knowledge about the Swedish AEC sector and digitalization. Building a ground to stand on was of essence, to understand which questions that had been researched and where there was a need of further research. Gathering information from different angles in relation to the research questions and aims of the report also led to an efficient questionnaire and interview questions, since the ability to ask correct questions was developed.

Reviewing literature was done with the help of platforms such as Google Scholar and Mendeley. Keywords were used to filter out and find relevant articles. Those keywords were for instance: *BIM, model-based construction, total BIM, digitalization in construction, innovation construction, organizational knowledge management, increased competitiveness and digital project delivery*. Depending on the findings in different articles, further research about the given subject was either done or excluded.

3.3 Questionnaire Survey

This chapter provides information on how the questionnaire was conducted. Both development of the survey and how the results were analysed is highlighted.

3.3.1 Development of the survey

The purpose of the questionnaire study was to analyse how the company works with digitalization and collaboration in digital systems and what the employees think about it. This was performed with the help of an invitation to four specific departments that work with the construction process together with the department of Project- and construction management. Managers of the departments helped with invitations.

The questionnaire was divided into three chapters. Background, digitalization at the company and project- and construction management was evaluated in the structured survey. To get results easy to examine and possibility to align together with questions easy to answer. An important aspect was the feasibility of the questionnaire. Since the trustworthy of the questionnaire depends on the number of answers, constructing an efficient questionnaire was crucial to gather a high percentage of answers within the study. Alternatives for answering the questions vary from multiple-choice, closed- and open-ended depending on the purpose of the question and feasibility.

The questionnaire aimed towards employees at Norconsult working on either of the four departments: Installation Technology, Structural Engineering, Project- and Construction Management or Architecture. With the help of department managers, the questionnaire was sent out to the employees at their departments with 60-80 potential respondents. 33 out of these responded to the survey (n=33). Titles among the respondents vary between building designer, plumbing designer, civil engineer, case manager, BIM coordinator, construction manager and architect. The ages, genders and experience also differed and there were representatives from ages between 20 to 60 years old.

3.3.2 Analysing the Results

Since the questions was asked differently with alternatives differing from closed-ended questions such as “Yes/No” and “0 to 5” to open-ended questions where the respondent answered with short sentences, analysing the results was adjusted to the best fitting method. The multiple-choice and closed-ended questions works well to evaluate statistically with methods to see trends and means.

The open-ended questions did not provide exact statistics such as close-ended do. The respondents answered in their own words, making it harder to find exact values and means. Although, open-ended questions provided great insight in what the employees think and believe about their situation and how it can be improved. There is a correlation between the closed- and open-ended questions where the unstructured data from open-ended questions are developed from statistical multiple-choice questions. However, the first chapter with background questions regarding age, gender and role was not furthered developed with open-ended questions.

3.4 Interview study

This chapter provides information on how the interview study was conducted. Both development of the study and how the results were analysed is highlighted.

3.4.1 Development of the interview study

The interview study lays the foundation for a qualitative analysis, aiming to understand the issues registered via the questionnaire survey. Open-ended questions were used so the interviewees could give their full perspective on the subject. However, the interviews were not limited to these exact questions, presented in Appendix B, but adjusted depending on the respondent. The interview structure consisted of two parts. A presentation about the thesis was given for the interviewee to understand the purpose, before asking questions about the interviewee. After that,

questions regarding the respondent's background were asked to gain insight in the persons knowledge and profession. The second part of the interview consisted of deeper questions regarding BIM. Two alternatives were developed for the second part. The first alternative was aiming for those interviewees which works with BIM daily. The second alternative for the second part aimed for those active within the AEC sector, but with other roles with less use of BIM.

The open-ended questions build on the issues registered in the questionnaire study. Experts were contacted and interviewed both internal and external. The external interviewees were supposed to give another perspective, including their beliefs on how the consultancy business operates and what can be done better. Internal interviewees on the other hand, were supposed to present how the company operates and what they believe can be done better to gain competitiveness.

The interviewees were selected with a purpose. Internal employees at the company were selected with the help of the group manager at the department of Project- & Construction management but not limited to the department itself. Strategists and project managers came from both Project- & Construction management and other departments such as Digital transformation and the Electrical department. The external interviewees were found via personal connections and checked if they had relevant background and information to contribute to the thesis.

3.4.2 Analysing the results

Analysing the results in the interviews was made by both notes during the meetings and going through and read the different transcripts. Citations were drawn out from the transcripts which had powerful and important meaning. Plenty of material was gathered, but also filtered to fit into the categorizations made by headings in the results. This was performed to stick to the subject. Many interviews contained great information but not necessarily within the limitations of the thesis which was filtered out.

3.5 Use of Artificial Intelligence

AI is enabling efficiency for many industries and efficiency together with productivity is what the thesis aims to investigate. Since the report is written during the spring of the year 2025, AI is a hot topic for all stakeholders. The thesis does not dig deeper into how AI can be utilized within the AEC industry. However, different tools are used for inspiration and solutions for the report. The main tool used to help the project is ChatGPT but has been limited.

AI is used for two purposes in the thesis. The first purpose was to explore and get inspiration. AI generated material is not used as a source for any parts of the thesis, but it possesses inspiration and answer easy questions which are important for the writer to understand. The second purpose was to use AI for translations and transcriptions. Both the interviews and questionnaire were in Swedish, so the translation was made with AI to fit with the thesis which is written in English. However, all this material was reviewed and adjusted manually.

3.6 Research ethics

The thesis involves multiple people from both the interviews and questionnaire. Respondents were informed about the background and purpose of the study. Interviewees were also asked if they consent to the interviews being transcribed. However, anonymization was made to gather results where they contribute with their own thoughts. This consent was given before transcriptions. Due to anonymization names and personal information are not presented, just their title and which company they work for.

The study does not contain material, which is neither personal nor sensitive, since the focus is on how the industry should develop. Sensitive personal data was not gathered. Additionally, the author focus on generalizations on the industry where multiple stakeholders and competitors can benefit from recommendations or conclusions. This higher the grade which the society can benefit and focus on development.

Another ethical aspect relates to sustainability. Digitalization is indirectly linked to efficient use of resources, which this report contributes to. The focus area and aim of the thesis is not environmental issues, but an area which indirectly can be affected with material from this report.

4. Results

This chapter present findings from both the questionnaire and interviews. First, results from the questionnaire study are presented. It varies between short citations from the open-ended questions and statistics regarding how the close-ended was answered. Secondly, results from the quantitative analysis are gathered both in the format as citations and summaries of the beliefs from the interviewees.

4.1 Results from questionnaire survey

This chapter present results from the questionnaire. A complete list of the questions is presented in Appendix A and the answers from questions 6, 9, 20, 21 and 22 are presented in Appendix C. Citations are used in the chapter to represent the full picture with different perspectives.

4.1.1 Background

The first part of the survey consisted of questions regarding the respondent's background. Out of the 33 answers the department of HVAC contributed with 13 answers, Project- & Construction management with 7 answers, Structural Engineering with 5 answers, Architecture with 6 answers and Installation – Electricity with 2 answers. Summarized the responses have different perspectives from the different departments which is important for trustworthiness of the study.

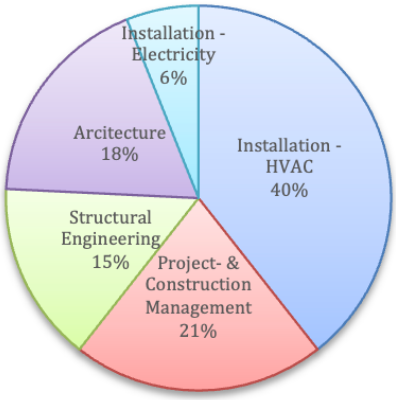

Figure 4.1: *Departments the respondents work for.*

The point of view may also vary between people educated in different decades, especially when it comes to digitalization. It was therefore important to gather answers from representatives with various ages. Almost half of the respondents were between 31 and 40 years old, 16 out of 33. 41 to 50 years had similar respondents as 20 to 30 years old employees with 7 and 6 respondents. 4 respondents were between 51 and 60 years old and none were over 60 years.

Another measured factor was the gender of the employees. Three options were given: Male, Female or Other/Don't want to answer. 22 out of 33 were men and the other 11 employees were woman. Even if not all the employees which was invited to answer the survey contributed, this statistic gives an insight on the background for the employees with age and gender.

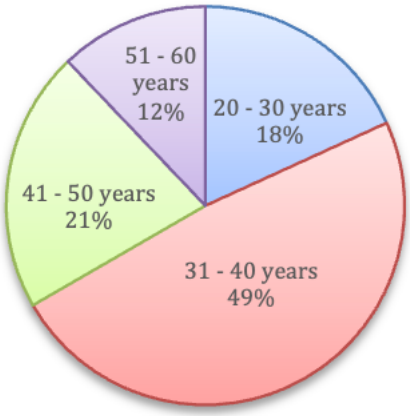

Figure 4.2: *Age spans of the respondents.*

4.1.2 In-depth questions

The in-depth chapter explored what the respondents think of the company and digitalization in general for the whole construction industry. This chapter consisted of 11 questions both open- and close-ended.

The sixth and first question of the second part was open-ended and requested the respondents to summarize what they know about BIM. Answers varied a lot between limited and basic knowledge from the school to much about how and where BIM can be utilized. Some of the respondents work daily with BIM and others has just heard about it. All depending on experience, role and department. Examples on answers from Q6 are:

"I would say I have good knowledge of BIM since it was a topic that came up many times during my education at Chalmers, but also something I work with daily. It stands for Building Information Modelling and is an information model that, for example, contains information about building components in a structure."

"Limited, but it is part of many projects I am involved in."

"I mainly work with calculations and do not draw much, nor am I particularly knowledgeable in the subject. I know that we work in the cloud in Revit on larger projects, but I have little understanding of how it impacts the work. I know who is responsible on the team, so I have someone to turn to."

"It is a digital tool for gathering information about a building structure to facilitate coordination within and between disciplines and to avoid unnecessary costs in later stages."

The seventh question was close-ended with the alternatives "Yes" or "No" to the question if they had heard about designs with the help of only digital solutions instead of the traditional 2D workflow. Almost 85% (28 of 33) answered that they had heard about it. Following up on these responses, almost 70% answered that they had been working in projects where the client requests 3D models instead of 2D models. It is completely logical that more has heard about it than people being involved in real projects.

The following answers were given as the reason for clients not raising the issue and order digital designs (Q9):

“I work a lot with municipal operations, and they are probably not at the forefront in this area. At least that is my guess.”

"It is new compared to paper drawings, and clients are likely inexperienced with it. Therefore, they choose something they are more comfortable with instead.”

“I think it becomes too expensive to model everything in the smallest detail.”

“Because they have too little knowledge about what a 3D model entails and how it can be used. I believe many are quite locked into using 2D drawings, as they have done for many years, simply to stay in their comfort zone."

“I have been involved in projects where we, as consultants, decide to include a 3D drawing to provide more clarity. I assume that clients feel they do not need to bring up the issue because we consultants make the assessment ourselves as to whether it is needed or not.”

The answers show that the perception and knowledge about BIM and digital solutions are limited. Having a comfort zone is also limiting the innovative mindset, doing the same things now as twenty years ago.

However, over 90% (30 of 33) answered that they have been working in projects together with a BIM coordinator. The question only had two alternatives, “Yes or No”, with no opportunity to develop further. Even if descriptions on how and why BIM coordinators are involved in their projects, these respondents clearly have been involved in project where stakeholders find an interest with BIM. The eleventh and following questions asks the respondent to answer if they work with programs linked to BIM, with a clarification on how much time they spend working with these programs. The alternatives ranged from 0 to 100%. The question was not mandatory which led to 32 answers out of 33 presented in Table 4.1.

Table 4.1: *Answers from Q11.*

Number	Percentage	Answers
0	0%	3
1	20%	9
2	40%	4
3	60%	4
4	80%	11
5	100%	1

The following question (Q12) explored which programs the respondents use in their daily works linked to BIM and digitalization. Revit, Dalux, Solibri and Other was fixed answers with the possibility to add programs. A clear majority answered Revit, 22 out of 33. 15 out of 33 answered Dalux as used in their work. Also important to mention is that 13 out of these 15 Dalux users also answered Revit. The same amount

answered Solibri, 15 respondents. Other answers were Navisworks, ArchiCAD, Bluebeam, Rhino, Grasshopper, Dynamo, Tekla and FEM-design.

Regarding what the employees believes of digitalization and the importance of an offer related to digital solutions to gain a competitive advantage, question 13 asked the respondents to scale their beliefs of this between 1 and 5. Option 1 was named "Irrelevant" and option 5 was "Very important".

Two respondents did not answer the question since it was not mandatory. The lowest chosen alternative was 3, and only 2 out of the 31 respondents chose that option. 4 out of 31 chose a 4 on the grading scale. This means that the majority, 25 of 31, chose "Very important" which was a 5 (mean = 4,7).

Question number 14 was similar to Q13. The respondents rated how important the company's internal work on efficiency using digital tools for maintaining competitiveness. The same pattern as the prior question, 31 respondents with a majority rating the internal work as very important. 21 employees answered the highest grade which was a 5. 8 responded with a grade of 4, and 2 respondents answered the neutral number 3 (mean = 4,6). Answered are visualized in a diagram in Figure 4.3.

Question 13 - How important do you think digitalization, and an offer of digital solutions will be for maintaining good competitiveness in the construction sector in the future?

Question 14 - How important do you think Norconsult's internal work on efficiency improvement using digital tools is for maintaining competitiveness?

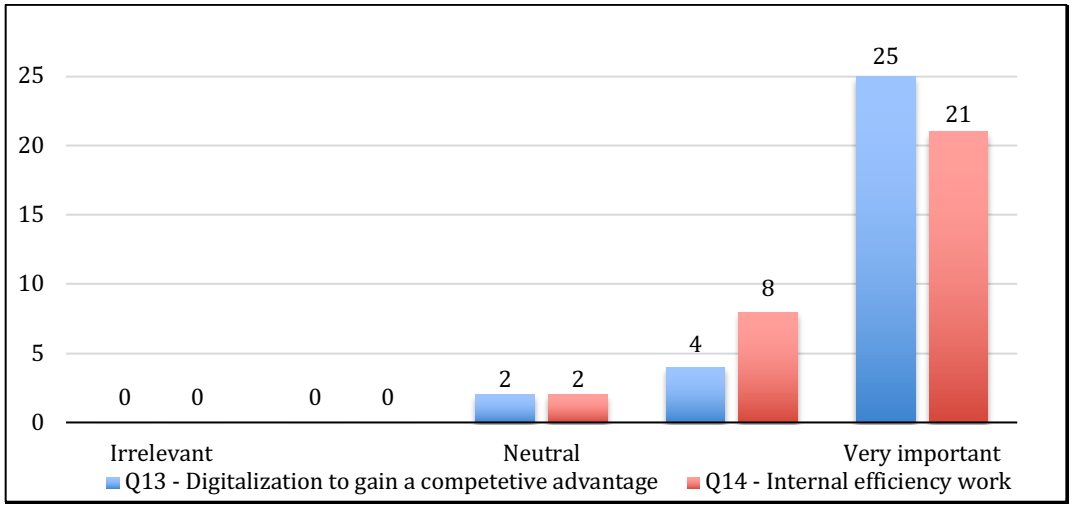

Figure 4.3: *Answers on Q13 & Q14 – Importance of digital strategies and internal efficiency work.*

Question number 15 explored what the employees think hinders digitalization and implementation of BIM within the sector. Fixed alternatives were presented with an option to ad own alternatives, so on top of the fixed alternatives, some respondents gave own sentences on what they believe hinder digitalization. The fixed alternatives

are presented in Table 4.2 together with the number of responses. One person did not answer on the question, so the total respondents were 32.

Table 4.2: *Answers on Q15 – Hinders with digitalization an BIM implementation.*

Alternative	**Number of answers**
Nothing.	3
Laws and Regulations.	3
Large proportion of projects with hourly rate (where efficiency is not always economically beneficial).	13
Customers are not asking for BIM or any other type of digitalization.	12
High costs.	4
Unfortunately, I have no/too little knowledge.	4
Attitude question for consultants.	11

In addition to the fixed alternatives in Q15, the following answers were given:

"Increased cost in the initial stage if you want to use BIM in existing buildings, which is what we work with the most."

"Ignorance."

"I have never heard of anyone asking for it and if we don't have to, I don't think we will take the first initiative to start with drawing free projects. Otherwise, we often use Revit/Enscape/Solibri etc. in projects."

"IT Infrastructure, Management's attitude towards investment perhaps, we are not keeping up with AI development that could help us keep up with good BIM models."

"I can see that the interest in BIM is greater on the contracting side than on the consulting side."

"I would say that there is a need for a skills upgrade on the client side."

The final question of the second chapter explored what the employees believe are the benefits of BIM in their own work. Question 16 also presented alternatives for multiple-choice with the alternative to ad own alternatives. Also, this question had 32 respondents.

Table 4.3: *Answers on Q16 – Benefits of BIM in your work.*

Alternative	Number of answers
No benefit.	0
Perform collision checks at an early stage.	28
Increase understanding and communication between departments at Norconsult.	20
Increased visualization.	31
Better project management linked to time and budget.	14
Efficient maintenance work.	17
More efficient renovations in the long term.	22

In addition to the fixed alternatives in Q16, the following answers were given:

”Automated processes.”

”Increased quality of documents.”

“Efficient way of working.”

“More efficient management/digital twins.”

4.1.3 Project- & Construction management

Question 17 asked the employees to estimate what proportion of their projects they work together with other departments. Ranging from 0% to 100%, options were given with 20%-intervals. Only 1 out of the 33 respondents answered 0%. 5 out of 33 answered 20% of the projects, and 3 employees answered 40%. This means that most of the respondents work interdepartmental in above 50% of their projects. 9 responses on 60% and 7 on 80%. This leads to 8 out of 33 employees work in interdepartmental projects 100% of their time.

The following question, question 18, explored what percentage of projects where coordination is lacking according to the employees. Like question 17, respondents were asked to grade from 0% to 100% and options were given with 20%-increments. Question 18 was also mandatory. 3 out of 33 responded that no projects had shortcomings in coordination. A majority answered 20%, 17 respondents. 6 employees answered 40%, and 3 responded 60%. The 4 remaining all responded 80% which leads to no answers on the option 100%.

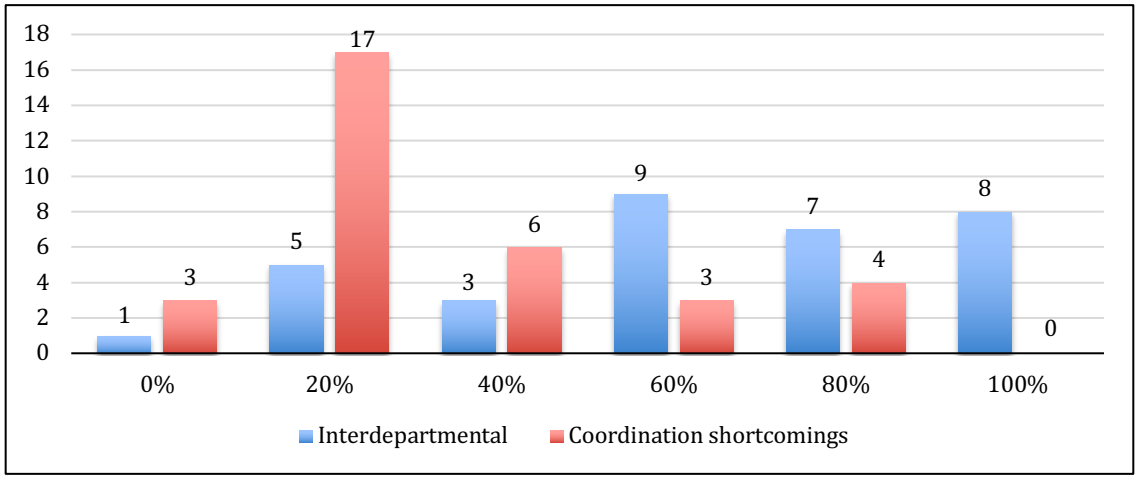

Figure 4.4: *Answers to Q17 and Q18 – Interdepartmental work and employee's beliefs on internal shortcomings.*

Question number 19 explored the reasons of shortcomings in coordination. Fixed alternatives were given together with an option to ad own sentences.

Table 4.4: *Answers on Q19 – Shortcomings in coordination.*

Alternative	**Number of responses**
No deficiencies	1
Poor understanding of other disciplines	13
Lack of communication	26
A view where different departments/disciplines consider themselves the most important	10
Poor planning and understanding of time	17

In addition to the fixed alternatives in Q19, the following answers were given:

"Do not know"

"Sometimes unclear what is expected of our delivery."

"Low interest in modeling correctly, thinking that it should look good on the drawing and not in the model. Understand the meaning of classifying objects according to BIP, BSABwr or CoClass."

"There are tendencies where coordination issues are taken more lightly, i.e. within NOAB."

The following three questions, Q20 to Q22, were open-ended where respondents answered in their own words. The first of the three asked the employees to describe on what they believe the company must do to strengthen their position regarding digitalization (BIM, digital twins, programs, education, AI etc.). In total, 25 responses were collected. The common theme in the answers is education and most of the answers relates to education in tools and how BIM can be utilized. Other answers

relate to management commitment and guidelines together with a more proactive approach.

"More structured mandatory training and permission to allocate time for it. Not everything can be learned solely through projects."

"Clear design guidelines on how we can work most efficiently with BIM in projects."

"A clearer strategy from management regarding BIM. Hire a BIM manager, an experienced BIM specialist who sees the bigger picture and the needs."

- Answers on Q20.

In question 21, the employees were asked with a broad question what the company can do to minimize risks and costly mistakes. 20 out of the 33 responded with sentences and their thoughts. A big variety of answers, but knowledge management is a key takeaway. The company must work and coordinate with transferring knowledge between projects and employees.

"Have a well-developed and clear coordination strategy for general consulting assignments. Continue developing staff in BIM."

"A clearer strategy from management regarding BIM."

"Project managers should be involved at an early stage to ensure that the correct materials are included as soon as possible. Changing materials later is a common cause of incorrect materials being included in BIM models."

- Answers on Q21.

The final question of the questionnaire asked the employees to think freely and reflect on how they believe they will work with digitalization and BIM within five years. 24 answers were gathered with a wide variation of themes. BIM and AI are main areas the employees discussed together with the emerging digitalization for the sector. Efficiency with digital tools is stated in most of the answers. Some are nuanced with skepticism regarding a full implementation shown in the citations below. Others believe that AI will replace BIM.

"It will become an absolute prerequisite for working with design and planning. I believe our industry is on the verge of a major leap in digitalization."

"Probably similar to today… But hopefully, AI development will have made it easier to automate workflows in modeling software so we can spend more time on other tasks."

"It will probably never completely replace drawings on construction sites. However, it will play an increasingly important role throughout the entire construction and management process."

"As a project manager, visualization and clash detection are the most important aspects and will continue to be just as crucial in five years. Being able to visually present change orders or other adjustments to the client can be improved."

- Answers on Q22.

4.1.4 Differences between departments

There were variations depending on the department the respondent works for. According to Figure 4.1, 7 of the respondents came from this department. One of these respondents did only answer the mandatory questions.

Question 11 asked the respondents to grade their time they spend in programs linked to BIM in percent. The mean of all 33 respondents was 49%. However, employees at Project- & Construction management answered a mean of only 10%. So, if this department is not accounted for, the rest of the respondents have a mean of 58%. These variations can be seen in Figure 4.5.

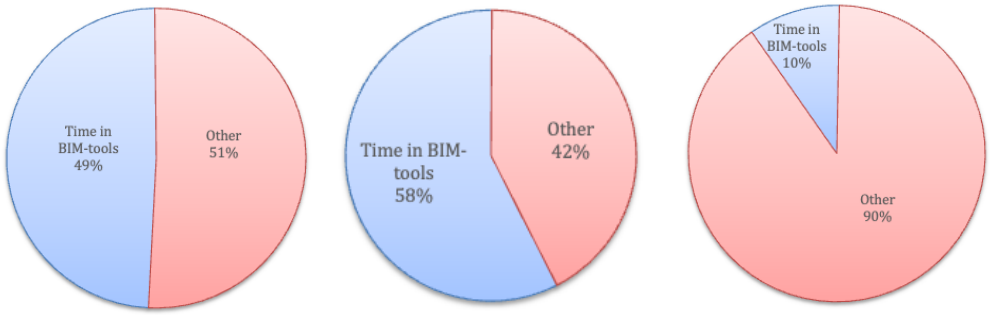

Figure 4.5: *Comparison time spent with BIM-tools, Q11. 1 - All respondents. 2 – All except Project- & Construction management. 3 - Project- & Construction management.*

Question 13 and 14 researched on how important the employees think digitalization is to keep competitiveness and the importance of internal work. Both questions had in general high means and employees believe both have high importance with means of 4,7 of 5 and 4,6 of 5. All respondents employed at the Project- & Construction management department all graded the two questions with 5 out of 5.

Question 17 asked the employee to estimate which percentage of their projects they work together with other departments. The mean of all employees was 64%. Interdepartmental work was higher for the Project- & Construction management department with a mean of 74%.

4.2 Results from interview study

The chapter presents an analysis on the interviewees. Combinations between citations and text on how the interviewees reason and think about the four different subchapters: BIM in Sweden, positive outcomes with BIM implementation, barriers and organizational knowledge management. A short list of the interviewees and their background is also presented below.

Table 4.5: *Interviewees and their background.*

	Role	Company	Date	Location
Interviewee A	BIM Strategist	Norconsult	250311	Office
Interviewee B	Project Manager Digitalization	Byggstyrning	250312	Teams
Interviewee C	Construction Site Manager	Tornstaden	250320	Construction Site
Interviewee D	Division Manager Operations	ZynkaBIM	250321	Teams
Interviewee E	BIM Strategist	Norconsult	250324	Teams
Interviewee F	Project Manager	Norconsult	250325	On site
Interviewee G	BIM Coordinator	Norconsult	250409	Teams
Interviewee H	Project Manager	Norconsult	250415	Office
Interviewee I	Entrepreneur	Serneke etc.	250515	Office

4.2.1 BIM in Sweden

According to several interviewees, with citations seen below, how the region and country enable and pushes BIM has a big impact in implementation. Framework and legal requirements are crucial in the construction industry and therefore something BIM depends on. All countries differ in between, and the legal requirements lays the foundation for how companies and organizations can work. Priorities differ a lot between continents and countries varying from efficiency, working hours, price, safety issues and environmental aspects. Digitalization differs depending on these priorities. Interviewee A discusses and gives an example on how the Norwegian industry compare to the Swedish.

"It's really interesting, but I haven't quite figured it out yet. In Norway, they have the Norwegian Transport Administration. I'm wondering how they have reasoned in accepting that we make drawing-less deliveries, where we deliver three drawings for an entire infrastructure or bridge project, while in Sweden we deliver a hundred or fifty drawings."
– Interviewee A

Since Interviewee A works for a Norwegian company in Sweden lessons can be learned from the colleagues abroad. The gained knowledge from Norwegian projects could possibly be used in the coming years during digitalization of the Swedish sector. Furthermore, it is also discussed how even sectors on the national level varies a lot depending on economic gains and an innovating mindset differing between sectors such as buildings, infrastructures and industry. Interviewee G also discusses how far they have come in Norway compared to the Swedish sector. It is mentioned that Norway has a set classification system which the state has developed. Since all projects use it, it becomes a standard for the industry.

"On the building side, they are getting very good at setting requirements, and designers are usually very familiar with that. But in smaller installation-type projects and more infrastructure projects, it's more about providing support and helping with those first steps."
– Interviewee A

Interviewee E emphasizes how the Swedish sector is slow, but also how the Swedish Transport Administration has hinted about their commitment to require open file formats. his is of essence to get a standardization for all kinds of projects where the demands and workflow are equal. Similarly, standardization is lacking in the Swedish AEC sector. Even if there are thousands of people working within the industry, we have no clear leader in development for digitalization yet compared to what Norway has.

"The construction industry is just crazy in many ways. There's no clear structure for how data should be presented. Sweden hasn't really managed to agree on how to name a component. There's a huge lack of standardization in the Swedish construction industry. Many people have strong opinions, but no one dares to make a real decision or take the lead. Also, a manufacturer might not even exist anymore. So, what should we use instead?"
- Interviewee E

The different clients in Sweden are on different steps in their development. A reoccurring problem recognized by many of the interviewees is the lack of standardization. Public clients are decentralized and do not have a common system. Interviewee G mentions three clients with a bit higher digital demands than others. Although, Interviewee B has been involved in Swedish projects where the whole project handover was made with digital models.

The City of Gothenburg is mentioned to have strict requirements for what they want and on the forefront. Interviewee G states that Akademiska Hus which also works with the City of Gothenburg as a client also have high requirements. The third and last is Stockholm's school properties and their guidelines which they focus on a lot trying to standardize something digital.

Interviewee F discusses how sectors nationally in Sweden differ. Related to BIM, the industrial sector is described to have come further in development than the construction industry. The highly detailed models are presented as a clear difference, where the industrial side involve details such as bults. The differences are described as cultural between construction and the manufacturing industry.

4.2.2 Positive outcomes with implementation of BIM

Many of the interviewees argue for significant value when implementing BIM in construction. An important aspect is the central hub a digital tool can work as involving all stakeholders from designers to inspectors. Clients are described by Interviewee B to not always drive implementation of BIM forward, but it is up to the consultant to find the most efficient way possible. However, the advantage a facility owner gets by a model after completion of a construction are big but unexplored to its

full potential. Interviewee B discusses that the majority of stakeholders benefit from BIM specially since the information is not locked in a 2D document which is hard to re-use. The model can save time and enable faster decision-making if used correctly.

"Since the 3D model has been the only official document, it also becomes the as-built documentation for the client. This means they receive an updated 3D model of their entire property that is 100% accurate when the project is completed. Instead of just receiving a set of drawings, they get a highly detailed and precise digital twin of their property."
– Interviewee B

Implementation is not limited to new construction. There are possibilities to also work digitally with old buildings. Interviewee B argues that commercial properties are a clear example of when this can be implemented. New tenants have different needs from the old ones, and layout of the building may be re-constructed. Methods as scanning is performed to model the construction accordingly. The size of the re-construction is crucial, and just changing simple walls and layouts might not be simplified with digital tools. However, greater re-construction of warehouses and big buildings has huge potential for digital tools to work efficiently.

"Then you get laser-scanned data and model everything based on the actual conditions, making strategic decisions on the level of detail depending on the type of building and its purpose. Continuously updating the model as demolition, construction, and structural changes take place is essential. You need laser scanning to keep the model up to date."
– Interviewee B

Laser-scanning is something Interviewee D has a lot to say about. It is a tool which can be used for all kinds of projects. The customers for the company and division the interviewee works for order laser-scanning for their buildings. The outcome of the scanned environment is a point-cloud which later is processed by constructors. Especially for larger renovation projects, scanning is a method which can decrease both time and costs for the project. The outcome which is processed by the constructors can build a BIM model and therefore is a part of digitalization within the industry. Compared to measuring by paper or even on-site, laser-scanning truly has a great potential increase in usage over the upcoming years.

Implementation of BIM is heavily dependent on the will of the stakeholders within the project. Interviewee B argues that putting focus on digitalization even in the tendering process is important, so that the right contractors and consultants can be chosen accordingly. Over the past decade, a major challenge has been shifting from drawings to models. However, entrepreneurs and consultants understand that they need to adjust to keep their competitiveness in the AEC sector.

Stakeholders interest highly depends on their own benefits. Consultants and contractors adjust depending on the needs and agreements during the procurement. An important stakeholder who decides a lot is the client or property owner. Interviewee B describe that the incentive for the client is a smooth construction finished on time and within budget. How this is reached is then up to the consultants and contractors.

Therefore, implementation lays more on their side to increase their efficiency and gain the competitive advantage modular construction comes with.

"Most property owners aren't too concerned with how we solve things. They just want a well-finished building, delivered on time and within budget and with a satisfied tenant moving in. Whether we achieve that with drawings, models, or some other method doesn't really matter to them."
– Interviewee B

Interviewee C works for a contractor company and reason on the same line as Interviewee B, collaboration is of high essence for successful project and unsuccessful projects often have a common ingredient which is lack of collaboration and communication. The property owner does not have a clear guidelines on how the contractors operate, but care more about the outcome and results. Improving collaboration is important to get profitable projects. However, modular construction was found as an unfamiliar concept.

Interviewee G also discusses how efficiency with BIM relates to the construction site. Instead of keeping hundreds of 2D-drawings, the 3D-model increase productivity with daily operations. On top of this, coordination is found as a main argument where digital models are efficient and minimize the potential costly risks with poor collaboration from the site management.

Building on the fact that consultants could be more selling on what they do, aiming for the right stakeholders is important. Interviewee G argues that clients may be difficult to sell and change their mindsets since they have their own management programs and fixed ambitions. The opportunities might be more on the contractor's side according to Interviewee G. For instance, they can benefit from timelines during production by getting schedules from a four-dimensional model. Interviewee C who works for a contractor company also see radical changes and high efficiency if they could make use of these tools. It is mentioned that quantity measurements is an area where the digital model can be utilized. Instead of counting everything by hand on drawings, quantity take-offs can be made with a high degree of efficiency and much less time for site management.

To succeed with implementation of BIM, Interviewee D further discusses on the interest of the facility owners. The net operating income is what they try to increase. Initial investments must pay off in an economic perspective. Stakeholders always strive to maximize their profitability and efficiency and for the property owner it is clearly the net operating income, meaning income minus expenses. Additionally, Interviewee D pinpoints that demonstrating the benefits and that they outweigh the effort is the successful method. Showing a concrete case or numbers will increase understanding for people not educated within BIM.

"Is there anything underperforming in my building that I need to take a closer look at, in order to make an investment short-term that could reduce my costs in the long run, and so on? So again, you have to start from that point. What is in the best interest of the respective stakeholders? For a property owner, it's the net operating income."
- Interviewee D

Interviewee G believes that standardization can be made with the help of giants such as the Swedish Transport Administration. Standardization is an important factor to consider for a full-scale implementation with BIM. Standards within all kinds of areas is what form and shape how different organizations increase their expertise. To have a competitive advantage, it is also of high importance that you can follow the standards put up by the big clients. If the clients such as Swedish Transport Administration clarify how the project delivery must be shaped, all companies will adapt to the same system.

Interviewee F, as many other interviewees, pinpoints the economic benefit also consultant companies can do if better tools are made. Faulty documentation is for consultant companies a big risk since their organization is only providing expertise and services. When this expertise and service fail, it is costly for the company. Decreasing these mistakes will ultimately lower the risks and hourly rates. Clear measurements and examples would according to Interviewee F be a good tool to show management how initial investments matters over time.

"We're probably quite pro, so I would like to look at how much Norconsult pays in errors in documentation. It's kind of a way to use this as a metric too, to be able to measure whether things are improving. I would think that if we had much greater digital expertise, our list of what we must pay in compensation for our faulty documentation would be much smaller."
– Interviewee F

Interviewee I argues that finding the right level which fits everyone is important. Adopting the pace of digitalization and BIM to what the experts believe is possibles would lead to failure. Setting up aims and goals together between the disciplines or departments. Sitting around the same table early on is mentioned as an important step where everyone has a saying. A parallel is drawn to the 1990s when a company came with demands that the site managers should use computers instead of paper and pens. Even if the team on site were sceptic about the change, Interviewee I argues that BIM can make a similar impact as computers did during 1990s.

4.2.3 Hinders & barriers

The client plays a big role and work either as a barrier or innovative enabler. The client's requirements have not developed at the same pace of digitalization for the past thirty years according to Interviewee A. As a reference, the Norwegian Transport Administration and their demands differ from the Swedish Transport Administration. Transport administrations work with big infrastructure projects, a business with slow progressions. However, the Swedish Transport Administration has flagged for development during the next few years.

"Attitude also if we believe enough that we can. We solve this and can sell it to the customer and then we can maybe also move forward. But I think that since it is very new in infrastructure, it is very much on the client side that they have their requirements - this is how it should look, and it is very similar to what we had in the nineties. But as I said, the Swedish Transport Administration has flagged that within a few years they will have IFC 4.3 as a requirement."
– Interviewee A

Additionally, Interviewee D agrees on that stakeholders are not well educated and know about the upsides with BIM. This varies depending on the persons background, and young people tend to easier see the benefits with a digital workflow. The customers which have shifted to more digitalized processes with the help of the company Interviewee D works for has been satisfied. More and more realize the upsides but is still not fully established within the industry.

"I'm not in the sales department, but when I talk to my colleagues, I get the impression that it's still generally necessary to explain the whole concept how it works and what the benefits are. That is to me an indication that it's not yet fully established in the industry or that people have not really realized the concept yet."
– Interviewee D

Overall and according to several interviewees, the mindset of stakeholders is what often hinders a full-scale implementation of BIM. Stakeholders focus on deliver the needed outcome in the most beneficial way for themselves. Doing the same thing that has worked in projects before is in many cases hindering implementation. From the consultant's side, delivering information of high quality is a top priority. If the delivery is done incorrectly, the risks of lawsuits and additional works are inevitable. The easiest way to ensure quality is to do what the person is best at, using the same strategy as projects before.

Interviewee A discusses that a big risk for consultant is that incorrect information can be delivered. Low quality and bad reviews increase the risks with a project, which unfamiliarity in reviewing information in a model instead of drawings can lead to.

Interviewee B agrees with Interviewee A but is working primarily with digitalization of the construction process, driving the use of model-based construction forward with minimization of traditional 2D-drawings. Another subject Interviewee B brings up is the pace of development in the digital tools. Not much has really changed, and the same tools are used where progress is slow. Since the tools are not designed for generating detailed models they often crash if pushed too far. Faster pace in the development of these tools would according to Interviewee B enable a better use of BIM.

"More effort is usually put into the drawings because everyone knows those are used. Even if people say, "No, we'll focus on the 3D models, but we have the drawings just in case,". The reality is that the drawings will still be used because they're familiar. People feel more comfortable with them, so they default to looking at the drawings and end up ignoring the 3D model. They don't want to take the time to learn it. But if we decide to rely only on the 3D model, people are forced to learn it. Then they realize it's not that complicated and they start accessing much more information."
– Interviewee B

The same pattern is also seen by Interviewee C. It is described that the sector Interviewee C works within has not changed their way of working for at least 12 years. Even though the used tools have been improved and updated, there has been no big change for the processes related to digitalization. The company Interviewee C works for is operating as a construction management company. Employees as both

engineers and project managers are using the same systems and methods as always, since they know how traditional drawings work. Interviewee C also emphasized that construction management companies will do what is necessary, and don't focus on development if there are no clear incitements for themselves.

4.2.4 Organizational knowledge management

Managing information and knowledge in an efficient way lays the foundations for successful projects (Rowley, 1999), which is also supported by several interviewees. A consultant company has experts within the different departments. The department of Project- & Construction management has expertise by leading construction project from the early stages to completion and project delivery. However, project managers do not always have knowledge on when digital solutions such as BIM can and should be utilized. Collaboration between the departments is of high importance, since knowledge on when advising an expert on a specific topic can free up time and recourses. Interviewee A discusses that there is a need of lifting knowledge for project managers on where BIM can be utilized. Understanding the digital requirements is of essence to succeed with the different projects, so understanding the importance and when BIM Coordinators should assist is important.

"We would win lots if we can find a good collaboration between BIM coordinators and project managers. They have worked much with demands and such things, but project management is not natural for a BIM-coordinator, even if you are put into such a role. We would gain a lot with basic knowledge regarding project management, how to lead a group. You need to communicate and exchange knowledge."
– Interviewee A

Education, transforming information and spreading knowledge internally within the company is claimed to ultimately free up time and recourses. Interviewee A further describe the thoughts on how an organization should work and how the strategy should be laid. The traditional small conferences maximized to gain knowledge on a specific topic or tool might not always be efficient. Instead, focusing on knowledge transformation daily can provide great value.

"But it's rarely those that actually provide value with just a two-day training. However, I know there is an initiative. Every Wednesday, they [Norconsult] *run a short lecture for 15 or 30 minutes. You can log in and join to see specific projects or take part in a short training session on reviews. For example: How do we work with model reviews? Here are help files, and here is a template - this is one way it could be done."*
– Interviewee A

Interviewee G also mentions how knowledge transfer is efficient with short sessions. Even if the interviewee works with digitalization and BIM, knowledge transfer in general can be made during short meetings. Focusing on transferring knowledge between and outside the individual projects prepare the employees for upcoming problems in other projects which limits risks. An example of this is arranged tech lunches where knowledge is spread during presentations of different examples of technical solutions or successful projects.

Gaining a competitive advantage is done by standing out from all competitors. Interviewee B argues that consultancy companies in general should sell what they do in a better way, showing what they can do and how they are positioned as a leading company. An innovative approach to problem solving give loads of opportunities. The company Interviewee B is working on put clear demands early in the procurement that all involved stakeholders within the project must have the digital approach. Initiatives also from the consultant's side would be an investment for future competitiveness.

"Consultants should be better at selling what they do. They are the ones creating all these 3D models and are the go-to experts for developing BIM models. I think there should be more interest from them in elevating this to a management level - showing the value and possibilities. The drive for change should come more from the consultants as well. Right now, it feels like we are the ones pushing them, while they are holding back a bit. I would like to see more initiatives from consultants taking a more innovative approach."
– Interviewee B

Having insight in how both the consultant company operates and how the department for Project- and Construction management works, Interviewee E discusses the major areas for improvements regarding digitalization and that some methods can be outdated. The major issue is the knowledge on how the presented models also can be used in other cases in a much more efficient way with cost estimations and measuring. Without blaming either side both transferring knowledge and the reception of information is important. Finding solutions where educated experts can help and increase efficiency for others in the company is important for future competitive advantage. Interviewee E provides an example where processes can be more efficient and that the department of Project- & Construction management sometimes use outdated methods such as scale rulers on drawings.

Interviewee E also emphasized how different departments within the company has differences regarding their digital development. Another mentioned department works with special projects with lower competition. Therefore, they can also focus on finding smart solutions such as BIM. Comparing it to Project- & Construction management where the competition is always high, hourly rates and finding cheap solutions is of more essence to keep the competitiveness. It would although be of high importance to find smart solutions and services so when a customer requires something it is already in place.

Since consultants usually work with hourly rates instead of fixed price projects, this can be an alternative for the future to investigate. Customers aim to lower costs and the projects play a crucial role. Consultant companies should aim to present alternatives which satisfies the needs of both customers and them, and the same goes for the clients. Interviewee E recognize that there are differences between the different departments when it comes to competition in projects. The competitiveness can both reduce and increase innovative solutions and development. It is argued that the hourly rates must be kept low and is the deciding factor during procurement, something that does not stimulate the need of internal development. The Swedish

procurement laws for the public sector plays a crucial role and sometimes also limits innovation.

"We have it pretty good when it comes to those who work on the department for power lines, for example. They have much less competition there than we do. That's probably the big thing. The problem is that there's so much competition for the general projects for us, you know. So, we can't really go outside the framework that much."
– Interviewee E

Interviewee G is working with digitalization internally. The production from the digital tools is not used to its full potential. There is room for other departments, contractors and the client to use the benefits in a better way. Reduction of time and money spent would be a possible outcome, but knowledge transfer must take place for the different stakeholders to understand the solutions and upsides. Interviewee A also see the same pattern and as a BIM strategist a part of the work is to push everyone forward and advise. It is also seen that individual driving forces are important, so therefore Interviewee A see that different technical areas have come further than others.

"Trying, just as you say, to be a bit competitive there and come up with digital solutions, we're trying to stay a bit ahead of the curve. What we can offer with our tools... We produce a lot in our tools today, but we only use a fraction of what we can actually get out of them. If you look at the interest from clients and contractors, then we can probably get a bit more out than we do today."
– Interviewee G

Another issue Interviewee G brings up is the essence of clients. The projects must align with the corporate strategy. Exposing towards customers and projects who stimulate the internal development should be prioritized. Even if the economic interest is important, seeing the bigger picture where employees and the organization can flourish is of significant essence to gain competitiveness in the long run. Promoting internal development will increase competence and position the whole organization in a better way for the future.

Interviewee F has been operating in the industry for decades and positive for digitalization. It is pinpointed that creating a feeling of success to succeed with transformation. Often, learning new things takes both time and effort so clear advantages must be pinpointed so the employees believe that their investment in time will be beneficial in the end. Increasing awareness and understanding of a solution would according to the interviewee change people's perspective on how different problems should be solved. Therefore, showing clear advantages with a new way of working is important if you want people to change their habits.

Interviewee I discusses how the consultant industry operates. With knowledge on how the different construction processes work, it is argued that prices based on time is not the most efficient since people work hourly and not always for the benefits of a project. Leaving prices based on projects give the best possible outcome for the clients according to the interviewee. Overworking a sustainability report or BIM model is mentioned. Re-inventing the wheel does not save money. However, AI is

mentioned as a solution to this where both time and money can be saved for multiple stakeholders and companies in the construction sector.

"So really, what did it actually help us with? Unfortunately, it's that kind of soft image. So, when it comes to sustainability, digitalization, in general, BIM there's a lot of that kind of thing people hide behind, saying that men have a higher level of knowledge now and then."
– Interviewee I

5. Analysis and Discussion

This chapter discusses the material gathered from the empirical analysis, both questionnaire and interview studies.

5.1 BIM within the construction industry

The literature review states that BIM is a game changer when it comes to digitalization within the construction industry, as higher productivity is the main outcome. Most of the answers showed either how the respondent work regularly with BIM tools or how BIM is I some way an important part of their projects. Also, the question of what BIM is aligns between questionnaire, theoretical framework and interviews. More than just a digital representation of a constructions size and shape, BIM consists information of high accuracy which leads to efficiency in many different areas.

BIM is utilized for many different stakeholders and companies. Some even have their core organization and business idea related to BIM. Previous research (Bryde et al., 2013; Sampaio, 2021) shows how stakeholders such as clients, main contractors and consultant companies all are affected by BIM implementation since it works as a collaborative bridge between the different disciplines. Even if BIM is a well-researched area, a total implementation is expected to be developed during the upcoming years. Companies adapt depending on the market and its needs which has left room for organizations to specialize on construction with the help of digital models.

Model advantages is a clear parameter BIM enables but collaboration and interdisciplinary control could potentially lower the costs of a project significantly, with for instance: clash detections, delivery plans and less miscommunication leading to costly changes. This is a pattern seen during all stages of the thesis and something both Bryde et al. (2013) and Doan et al. (2019) discusses, also supported by the interviews and responses from the questionnaire. According to the results of the questionnaire, the benefits of BIM in the respondent's daily work was according to a substantial majority, clash detections in early stages. With about two thirds of the answers, the respondents lifted that increased understanding and communication between the different departments was crucial and a big benefit with BIM. Increased visualization was the winning alternative, which also can be related to increased collaboration.

Differences between the different countries and industries is supported both by literature and interviewees. The theoretical framework presents how the AEC industry differentiate from other industries. The uniqueness of the projects leads to a unique sector and Dolenc (2023) pinpoints how location, characteristics and constraints vary, so the project management must take those variations in consideration. How the teams are constructed also vary depending on the construction, which further differentiate the AEC industry compared to others such as the manufacturing industry. Variations between different countries and how far they have come compared to Sweden regarding BIM implementation are described by multiple interviewees. The Norwegian sector is brought up as a pioneer and that they have implemented more

digital project deliveries with the help of the Norwegian Transport Administration. Comparing the responses clearly shows how Norway has a more innovative mindset and leading the way when it comes to digitalization.

The lack of standardization is a major difference between the neighbours Norway and Sweden, leaving a big upside for the Swedish industry to draw lessons and follow the Norwegian lead. Even if some clients have started to adjust and demand more digital project deliveries, major actors such as the Swedish Transport Administration seems to have started their digital journey with commitment to requiring open file formats.

The industrial manufacturing industry seems to have developed BIM and digitalization more than the construction industry. However, Interviewee A recognize that the building side has come further in Sweden compared to infrastructure. Easy to state is that the interviewees have different perspectives and present arguments and reasoning behind how their area of competence should develop and be more like other industries and countries. It is important to keep in mind that pilot projects do not represent a whole industry but should not be underestimated when it comes to future potential.

Since they work with different things, it is reasonable that the respondents for answered questions differently in how they work and what they think about the future. The thesis aims to research knowledge transfer with digitalization for the Project- & Construction department and some variations could be seen on how they responded compared to the other departments.

5.1.1 Driving factors

A clear driving factor is profitability independent on industry. The main driving factor of BIM implementation is economic upsides even if there is an initial investment. When showing the profitability, it is important to keep in mind the interests of the recipient. For instance: A construction contractor would probably care less about the performance of a building in 50 years compared to the facility owner. At the same time, the facility owner would most likely not care much on how the daily operations for the construction contractor works with their internal delivery plans. Even if BIM can possess information for the two stakeholders, aiming the right information to the right recipient is of essence.

Lindblad & Guerrero (2020) claim that there are uncertainties if implementation should be led by suppliers or clients. It can be argued that some stakeholders benefit more than others with digital working, since it even leaves room for new roles and companies specializing on it. The question if implementation of BIM should be client- or supplier-led remains. Investments are done if there is an upside and BIM possess positives for almost all serious stakeholders. Therefore, the lead should be taken by all stakeholders such as consultants, contractors and clients to increase the productivity and potentially profitability. However, impact will be greatest if the major clients put up demands as presented in the pilot projects presented by Disney et al. (2024) and Ulutas & Gustafsson (2025).

One of these major clients with support from the government is the Swedish Transport Administration. The Norwegian equivalent seems to have standardized

processes and the positive approach to open file formats (IFC 4.3) from the Swedish Transport Administration shows that they try to improve with an innovative mindset. Smaller organizations will adapt quickly to the demands put up by those large clients and further push on the productivity for the Swedish construction sector.

The higher ambition with Total BIM where model-based construction is the core and only concept in a construction is enabled with BIM. Working with the model as a legally binding source has been working well in two Swedish projects New Slussen and Celsius (Disney et al., 2024; Ulutas & Gustafsson, 2025). Forcing all project participants to adapt is according to the studies a positive outcome and already in the procurement is an important factor. This is an example of client-led innovation. Innovation and ways of working which is supported by Interviewee B. Even if all interviewees support digitalization and see the positive outcomes with different angles, but as a project manager within digitalization Interviewee B has the full picture. Value creating for all stakeholders is brought up in the interview, but companies and consultants should be more innovative and selling on what they do. Collaboration is a key factor with is the main enabler to Total BIM. Ulutas & Gustafsson (2025) draws parallels which is that involvement was for New Slussen crucial. Sceptics such as contractors and workers was supported during the whole construction process, which would not be possible if collaboration wasn't a key factor.

Both BIM and Total BIM is not limited to the construction process. Many of the interviewees argues that management of the facility is more productive if the owner has a digital model or even a digital twin. Construction processes are finished in some years, but the buildings and infrastructure are meant to survive often over 100 years. Managing the facility might not have an annual cost the same as constructing but can be expensive within the span of 100 years. Reflecting and creating a facility which is easy to manage is important for the facility owner and should not be underestimated. Digital twins are described by Mihai et al. (2022) to enhance maintenance and monitoring. Daily operations can be optimized depending on the needs in a digital twin, ultimately lowering costs while increasing performance. From the questionnaire and Q16, about two thirds of the respondents believe that future renovations can be performed with higher efficiency and possibly save money for the facility owner. Interviewee D states that property and facility owners focus on the net operating income. Underperformances in the buildings are visualized with the help of digital twins and possibilities to make short-term investments for future savings are clarified.

5.1.2 Limitations and barriers

Data ownership is recognized by Smith (2014) as an issue. Neither ownership or cyber security is brought up as limitations by interviewees or respondents from the questionnaire. However, many recognize in line with Sundquist et al., (2020), that laws and other regulations hinder the digitalization. The focus must be on the digital models instead of traditional drawings. Interviewee B states that stakeholders focus more on the drawings if they are there as an alternative since it is the traditional documents everyone is used to handle. The mindset and lack of ambition could potentially limit implementation even if digital models are used.

Interviewee C describes that how contractors will not adapt just by itself. There must be an incentive for change, otherwise it is just consuming resources. Also, consultant companies focus on delivering high performance in their services towards clients. Incentives on innovative ideas and digitalization is what also pushes the consultant industry. Lack of these incentives are limiting implementation of BIM.

New ways of working are seen as a risk for many of the different stakeholders. Their area of competence and the profitability of their organization is not something they want to lose. Delivering incorrect information from the consultant's side is a risk according to Interviewee A. Unfamiliarity and going outside the box gives rise to potential economic losses. The same goes for other stakeholders which further increase skepticism for a change in the way of working.

5.2 Incentives

Lack of incentives is brought up as a limitation. Multiple or profitable incentives therefore also work as reasons for implementation in a bigger scale. Moreno et al. (2019) reason that clear incentives for the client are productivity and cost-efficiency. Benefits during the construction phase will save money for the client and facility owner which is visualized in Figure 5.1. This is the major reason for implementation of BIM or even Total BIM, not limited to only the client but also other stakeholders. Saving money is in everyone's interest. Designers, contractors and consultant all benefit from smooth project deliveries and a high level of collaboration. Responses from Q19 in the questionnaire showed that 26 out of 33 believe that shortcomings in collaboration are linked to lacking information. Project- & Construction management teams should focus on this where using a model can ultimately decrease these shortcomings.

Contractors and consultants adapt to the needs of clients. To keep clients and competitiveness, contractors and consultants must have an innovative mindset. Keeping clients and competitiveness is a clear incitement and adjusting to the market and future needs is an important way to do it. Preparing for change is the first step. The next step is leading the change. Even if clients place orders and decides, there are examples of when consultants can lead the change for them since they have knowledge and the ability. Interviewee D states that demonstrating benefits for the clients give opportunities for business, which is also the case for the organization Interviewee B works for. Consultants should and must be more selling on what they can do.

Within the report, different incentives within many areas for implementation of BIM are presented. Reasons behind implementation of BIM and a higher grade of digitalization can be found for almost all stakeholders. The downside is often linked to the initial investments. For contractors, it can be education for workers. Clients will have an economic cost linked to digital models and consultants must also educate and learn new ways of working. These investments can be both costs for the single project, or organizational where employees must learn and change systems. The single projects do not always profit from an implementation of complex digitalization, but organizations adapting to the market and taking a lead are profitable and productive.

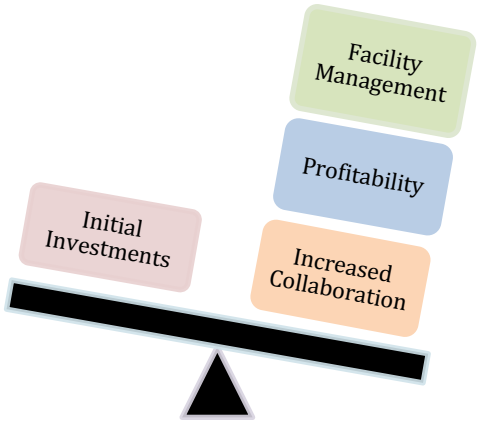

Figure 5.1: *Incentives for implementing BIM in an organization.*

Cities and municipalities can make us of digitalization and BIM after the construction phase is over. Creating a smart city where resources such as re-used material are accounted for and customizations in the urban design has its foundations in a digital model or even digital twin. Using both our infrastructure and buildings to their full potential increase efficiency and is important for cities sustainability. The incentives for those stakeholders therefore also relate to the future, since resource management is a subject where BIM and digitalization can give benefits during the decades to come.

5.3 Transferring knowledge

Organizational knowledge transfer has been important for competitiveness in decades (Rowley, 1999). Having systems for information and how knowledge should be transferred is crucial for survival. Struggling with this will decrease productivity within the organization. Just like construction projects where the control and flow are important, internal works for development and control is a stability for companies. Top management are responsible for shaping the organization in the most beneficial way. Focusing on employees and the flow in their work should be a high priority, and managing information in a good way enables a better flow. Using easily accessible knowledge and information with the purpose to make informed decisions will lead to more efficient processes. Smith (2014) states that organizations investing in BIM position themselves favourably, and the same goes for companies which has a systematic work with their knowledge around it.

Regarding what companies must do to strengthen their position within the area of digitalization. Allocating time, clear guidelines and education together with strategies from management regarding BIM were common responses. The same pattern is also seen in the interviewees. Employees would like to learn more find information in a better way, and solutions such as short presentations instead of investments in time-consuming educations are presented by some interviewees. Furthermore, this was also the case and a success factor for New Slussen (Ulutas & Gustafsson, 2025).

A majority of the respondents on the questionnaire thought that knowledge management is a key factor for success. Answers were gathered where employee's pinpoints development of themselves, clear strategy for BIM and early involvement of

BIM strategists in major projects. Internally, knowledge transferring can increase coordination for big companies. Interviewee A demonstrate that project managers often can make better use of BIM coordinators and the digital requirements. Education and transforming information are another subject Interviewee A brings up, and that the department has a session for 15 to 30 minutes each week for this knowledge transferring with various subjects each week.

There might be large differences in how companies should store and transfer knowledge depending on their size, culture and industry. Consultant companies might have many of employees with many different competences. It should therefore be up to the management to find the best solution and if it should be centralized system or up to the different departments themselves. Inexperience is a human factor which can limit the choice of digital workways when choosing approach. Ultimately, lack of knowledge and experience is highly contributing to slow processes and changes in the whole industry.

5.4 Discussion of methodology

The abductive analysis consisted of both interviews and a questionnaire. The number of respondents for the questionnaire and interviewees might lack because time must be spread on several areas. Focusing on one of these and choosing deductive or inductive approach instead would likely increase the quality of the interview or questionnaire. The same goes for handling the results. Still, the author argues that mixing approaches has given various perspectives which also is varies in detail. Numbers and statistics were gathered, but interviewees which provided their full perspective could at the same time reflect upon the statistics and give a better background.

Suggested area to improve for the thesis would be a clear strategy from the beginning, digging deeper into what the consultant industry needs in terms of suggestions on how their organizational knowledge transfer should work regarding digitalization and BIM. Open-ended questions were asked during the interviews, and interviews should be considered earlier in the timetable so professionals could give input earlier in their needs and what they would need to improve their work. These interviews could potentially be open and free and not relate to a specific subject more than for instance digitalization.

6. Recommendations

This chapter will present recommendations for the industry stakeholders based on the results from the theoretical framework presented in Chapter 2 and empirics presented in Chapter 4. The chapter is divided into subchapters aiming for consultants, clients and other stakeholders.

6.1 Recommendations for the consultant industry

Digitalization Together with Sustainability
Sustainability may be on the lips of the most people working with construction, transportation, manufacturing and many other industries. Putting environment first is for many clients a top-priority and Norconsult has multiple projects linked to this. Consultant companies should aim to work even more with projects with a clear sustainability ambition. This would also increase the internal knowledge for the consultants and position the company better for future projects.

Digitalization has also been a hot topic for the past decades and will most likely remain important over the decades to come. Involving digitalization such as recommendations with for instance BIM, AI or digital twins internally is important to keep productivity. Especially the hot topic around artificial intelligence. Also, focusing more on projects where digitalization is an important factor would increase knowledge and experience for the consultants.

Transferring Knowledge Internally
Knowledge transfer is important for the company to stay competitive, not limited to only digitalization. Not just recruiting but also developing current assets is crucial for success. The main and biggest asset Norconsult, such as other consultant companies, has is all employees. Building loyalty among employees and a culture where they strive together with successful and innovative projects would ultimately make a consultant company not just one of the leading consultant companies in the Nordics, but the leading company. The competition is high but not impossible to overcome.

The authors findings suggest that transferring knowledge can be directly linked to company culture. New employees are involved and productive sooner while senior employees still develop their skills even decades after their employment started. How knowledge should be transferred must be a question for top management to handle. The author suggest:

- Education with tech-lunches weekly.
- Guidelines for how the different divisions/departments should arrange their information regarding successful or failed projects.
- Involve successful pinpoints from projects on weekly/monthly department meetings.
- Draw lessons and establish ambitions with the help of departments from other countries (as BIM utilized in Norwegian projects).
- Developed mentoring, matching junior consultants with seniors depending on interest and ambition.

- Lecture from BIM Strategist during the digital sustainability week, showing successful projects.

Proactive – Understand client needs and innovative projects
The core of a consultant company is consultants working for clients. Working 100% of the time for clients is the main ambition for most consultants. The departments and groups are led by managers, who naturally work most of their time on internal questions such as recruiting, procurement and budget. The author suggests that the same is done for different focus areas where the top management believes future is. Top management may create these groups with consultant which has knowledge and interest in a main area. Their task would be to evaluate the market, the predicted future needs and orders from clients and competitors' ideas and pilot-projects.

Focus for consultant companies must be that consultants work full-time for different clients, but it should not hinder development and winning upcoming procurements. A group with a clear task to suggest how the company should position itself within a certain area would increase the chance of future competitiveness. This group should not necessarily work full-time with the task, but when the schedule allows together with group meetings on a regular basis.

BIM for Project- & Construction managers
An interesting question brought up in many of the interviews – Should project- & construction managers be better in BIM? The author argues that mission and project should decide, but it is not necessary for these managers to be better in BIM. However, a general knowledge lift should be made related to how BIM can help the managers in their daily work. Also, knowledge on when BIM Coordinators can help should increase. In some cases, and prior projects these coordinators have been involved to late in the process.

Project- & construction managers from consultant companies are often the ones with the most communication towards a client in a big project, even if other departments are involved as well. This also gives a possibility for them to suggestions regarding multiple things. One possibility is to increase the client's knowledge regarding BIM and perhaps make the client chose a more digital project delivery. To enable this, a BIM Strategist should be better linked to the department where project- & construction managers work.

6.2 Recommendations for clients

Clients focus on a well-executed project delivery, productivity during construction, net operating profit and satisfied tenants/investors. All these aspects should still be a focus point for clients. This is also the reason and the main incentive for them to increase their demands on digitalization with model-based project deliveries and digital twins. BIM reduce risks and can early in the process make clients take well-informed decisions with how the specific decision effects cost, environment or appearance.

Visualization before construction could satisfy the needs of many clients and a standard they should set early. An important positive outcome with model-based construction is future productivity. Digital twins are enabled, and clients could make

use of these twins for re-constructions or facility management. All kinds of projects and clients could benefit from this.

6.3 Recommendation for other stakeholders

As shown in the report, most serious stakeholders within construction benefit from the consequences BIM and digitalization brings. Efficiency and productivity during all construction phases brings savings in time and pure money for the involved stakeholders. The incentives for clients are clear where they are, according to the author, recommended to take a lead regarding their digital demands. This does not mean that clients are the most beneficial stakeholder with modular-based construction. Contractors get clear advantages if BIM is utilized. Counting material, collaboration with sub-contractors and reducing time for site management are among many reasons BIM implementation is potentially the most important change for the upcoming decades. Even if the client put their demands during the early stages, this does not limit contractors or other stakeholders to take a lead if clients lack initiative.

According to the findings in the report, contractors lack initiative and focus on deliveries which only fulfill client requirements. The author questions this fact - successful companies work with innovation and take a lead in all areas they can, not just doing as few things as possible for short-term savings. This would also position the given contractor company for future procurements and projects.

Lack of standardization is a subject brought up from many interviewees, independent on their area of competence. Major clients supported by the government such as the Swedish Transport Administration has a big responsibility. Commitment to IFC 4.3 is an example and if such a large client standardizes their requirements will lead to others following. This standardization is something the author believes will benefit all stakeholders in the long run and reduce risks. Often, having clear processes and established methods increase productivity but also the reason why companies might not take a lead within model-based construction.

Also, smart cities and digital twins may in the future increase efficiency and resource management within many different areas such as energy consumption, water use and traffic. Working more digital overall can provide a base for cities which they later can use in those areas. Taking an innovative mindset will increase the chance of future success within this area leading to sustainable cities.

7. Conclusion

This chapter will conclude and explore the outcome with the thesis. The conclusion goes back to the aim and the presented research questions with answers. The research questions are answered with the help of presented material from the thesis. Additionally, recommendations for further research are presented.

7.1 Answers on the research questions

Question 1: *What incentives are there for clients to order services related to digital solutions in the construction industry?*

The incentives for clients are many. First and foremost, clients should focus on net operating profit. Finding the best solutions with as high net operating profit is the main business idea for clients and facility owners. This is also the main argument on why clients should position themselves and drive the change of digitalization. Clients profit from efficient construction processes with lower cost. When the construction is finished, facility owners can benefit from the digital model in their facility management. This lowers the costs in the long run and decrease the time administration must put in during the upcoming 100 years.

Additionally, clients work with their sustainability goals can be better utilized with digital solutions from the construction phases. Choosing material and the design of the construction according to the sustainability ambitions is enabled with model-based construction. Also, re-use from the deconstruction phase is used with better efficiency if there is an updated digital model instead of old 2D drawings.

Question 2: *In which way can a consultant company use digital solutions to gain a competitive advantage within construction project management and how can knowledge transfer utilize this?*

Many consultant companies market their skills and services related to BIM and digital solutions. How these companies can get the competitive advantage relates to internal work and possibly acquisitions. Knowledge transfer can give a competitive advantage, but a condition is that there is knowledge which can be transferred. Focusing on recruiting and keeping leaders within digitalization such as BIM Strategist is of essence and giving them tools to educate others with their management in projects increase competitiveness and internal knowledge. Industry leaders seem to win more projects and be more profitable.

Consultant companies should aim towards the clients where potential is for future possibilities, also to satisfy development. Exposing towards customers and projects who stimulate the internal development should be prioritized. Top-management should provide clear strategies to the consultant company, aiming resources to the right clients. Also, focusing on how the company can increase knowledge within digital solutions in all departments is considerable. Lifting understanding for project- & construction managers on which areas where digital solutions can be utilized and when BIM Coordinators should be contacted is another point top-management should have as a set strategy.

7.2 Further research

This report focuses on how BIM can increase efficiency in construction processes, specially from a consultant perspective. Knowledge management and transferring knowledge within an organization is also presented as a recommendation in the thesis. However, responses from the questionnaire respondents and different interviewees touch upon many other areas which can be researched in the future.

The breakpoint on where BIM no longer is profitable would be interesting to research further. For instance, should BIM experts consult in minor construction projects and if there is a lower-end limit. Another subject to research is related to organizational knowledge management, with a case study creating guidelines digging deeper into how companies should work with knowledge transferring depending on the company's size and business model.

The thesis touches upon how clients should put demands with BIM and digitalization. Another suggestion for research in the future is on how major Swedish stakeholders should organize standardization with digital documents, just like 2D drawings required as building permits nowadays. One of the interviewees pinpoints that the consultant industry possibly could change in the future. How these companies should arrange fixed prices for projects, or how clients can demand fixed prices is a proposed by the author.

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Appendix A – Questionnaire

BIM at Norconsult

The background of the survey is a thesis project from Chalmers, conducted in collaboration with Project- & Construction Management at Norconsult. The research question revolves around drawing-free and more efficient construction processes using BIM (Building Information Modelling). Through your survey responses, a current-state analysis will be built to assess the conditions at Norconsult. The goal is then to propose measures to enhance Norconsult's competitiveness.

Quick facts: The origin of BIM is 3D-CAD. Instead of just elements, a BIM model contains more specific information about each part of the digital building – a digital model of the structure. This allows a transition from traditional 2D systems to planning and coordinating construction projects using the digital BIM model. The next step in development is a "Digital Twin," a living building whose information on flows and other aspects is updated regularly throughout the building's lifespan.

This survey is aimed at all of you in the departments of Project- & Construction Management, Installation Technology – Electrical and Ventilation, Architecture and Structural Engineering. Thank you for participating in this thesis project and for driving the development of both the industry and the company forward!

If you have any questions or even suggestions - feel free to reach out!

Ludvig Oom
ludvig@oom.se or +46 708 82 80 03

Chapter 1 - Background

1. Name?

2. Which department do you belong to?
- Project- & Construction Management
- Installation Technology – Electrical
- Installation Technology – Ventilation
- Architecture
- Structural Engineering
- Other…

3. What is your title?

4. How old are you?
- 20 – 30 years
- 31 – 40 years
- 41 – 50 years
- 51 – 60 years
- 60+ years

5. What is your gender?

- Male
- Female
- Prefer not to say/Other

Chapter 2 – In-depth questions

6. What do you know about BIM?

7. Have you heard of projects where the design is done without drawings, solely using digital solutions such as BIM?

- Yes
- No

8. Have you been involved in projects where the client requests 3D models instead of just 2D drawings?
- Yes
- No

9. If no: Why do you think no client raised the issue?

10. Have you worked on projects with a BIM coordinator?
- Yes
- No

11. Do you work with programs linked to BIM? If so - how much of your working time is spent on this? For example: Revit, Dalux, Solibri etc.
- 0% of the time
- 20% of the time
- 40% of the time
- 60% of the time
- 80% of the time
- 100% of the time

12. If you have worked with BIM, what program was used?
- Revit
- Dalux
- Solibri
- Other…

13. How important do you think digitalization, and an offer of digital solutions, will be for maintaining good competitiveness in the construction sector in the future?
- 1. Not relevant
- 2.
- 3. Neutral
- 4.
- 5. Very relevant

14. How important do you think Norconsult's internal work on efficiency improvement using digital tools is for maintaining competitiveness?
- 1. Not relevant
- 2.
- 3. Neutral
- 4.
- 5. Very relevant

15. What hinders digitalization and the implementation of BIM in the construction sector?
- Nothing.
- Laws and regulations.
- Attitude question for consultans.
- Large proportion of projects with hourly rate (where efficiency is not always economically beneficial).
- Customers are not asking for BIM or any other type of digitalization.
- High costs.
- Unfortunately, I have no/too little knowledge.
- Other…

16. What do you see as an advantage of BIM in your work?
- No benefit.
- Perform collision checks at an early stage.
- Increase understanding and communication between departments at Norconsult.
- Increased visualization.
- Better project management linked to time and budget.
- Efficient maintenance work.
- More efficient renovations in the long term.
- Other…

Chapter 3 – Project- & Construction Management

17. What percentage of your projects do you work with other departments?
- 0% of the projects
- 20% of the projects
- 40% of the projects
- 60% of the projects
- 80% of the projects
- 100% of the projects

18. In what proportion of your projects do you experience shortcomings in the coordination work at Norconsult?
- 0% of the projects
- 20% of the projects
- 40% of the projects
- 60% of the projects
- 80% of the projects
- 100% of the projects

19. What are the most common shortcomings in Norconsult's coordination?
- No deficiencies.
- Poor understanding of other disciplines.
- Lack of communication.
- A view where different departments/disciplines consider themselves the most important.
- Poor planning and understanding of time.
- Other…

20. What do you need from Norconsult to improve your work with the help of digitalization (knowledge about BIM, digital twins, programs, training, AI, etc.)?
21. Is there anything else Norconsult can do to minimize risks and costly mistakes?

22. Think freely - How do you think you will work with digitalization and BIM in five years?

Appendix B – Interview study

Background to the interview
The background of this interview is a master's thesis from Chalmers, conducted in collaboration with Project & Construction Management at Norconsult. The research question focuses on drawing-free and more efficient construction processes using Building Information Modeling (BIM). A current state analysis is built through survey responses. The goal is then to propose measures to enhance Norconsult's competitiveness based on insights from these in-depth interviews.

The interview is aimed at either professional with extensive experience in BIM or professionals involved in large construction projects. The first part is directed at all interviewees and covers background information. The second part is divided into two sections, depending on whether the interviewee has a background in BIM or another role in the construction sector.
Are you okay with me recording this interview and using your responses in my thesis, in the form of short citations?

First part – Background with personal questions
- What is your name?
- What is your educational background and professional experience?
- What is your current role, and which projects are you involved in?
- Briefly, how would you describe BIM?

Second part - Specific questions
Specific questions for individuals working with BIM
- How long have you been working with BIM?
- What do you see as the biggest enablers for BIM?
- How has the industry changed in this area over the past five years?
- What are the biggest challenges in implementing BIM?
- How can a project organization work to minimize risks and costly mistakes?
- Can you provide brief examples of how BIM has improved efficiency in projects you have been involved in?
- How do you think construction companies should work with BIM to maximize its benefits?
- Are there other digital solutions that the industry needs?
- Do you have anything else to add?

Specific questions for individuals working in the construction sector
- Have you used BIM in previous projects? If so, how? Was a BIM coordinator involved?
- What do you see as the biggest long-term benefits of drawing-free construction?
- How do you think the industry will develop in this area over the next five years -digitalization?
- What can companies do to prepare for this development?
- How would better access to 3D models instead of traditional 2D drawings make your work easier?

- Are there other digital tools or solutions, besides BIM, that the construction industry needs?
- How can a project organization work to minimize risks and costly mistakes?
- Do you have anything else to add?

Appendix C – Questionnaire Answers

Question 6. What do you know about BIM?
We work with BIM tools such as Revit. Modeling tools with a lot of information about various things.
It's a broad term :) But for me, it’s about the flow of information in 3D models. Establishing a structure early on, including files, to facilitate project planning/coordination. It is desirable for us to work more towards a drawing-free and 3D model-based approach. To work with digital twins, a high level of BIM maturity is required in the company.
Quite a lot.
BIM is an incredibly large and broad concept, making it difficult to answer the question. What is the purpose?
Basic knowledge from education.
BIM (Building Information Modeling) is a digital process for creating and managing information about a building or infrastructure project throughout its lifecycle. This means using an intelligent 3D model to facilitate planning, design, construction, and operation.
The information I have about BIM is overarching. I acquired my knowledge from Chalmers and CAD courses in high school.
What you mention in the introduction to the survey - that it's about incorporating more than just the building’s shape and appearance into a model. Also including information about various building components, such as lock details on doors, etc.
A 3D model where each building component contains full information about its content. For example, one can extract material lists to check how much gypsum is needed on the second floor and order the correct amount for the right place, etc.
I would say I have good knowledge of BIM since it was a topic that came up many times during my education at Chalmers, but also something I work with daily. It stands for Building Information Modeling and is an information model that, for example, contains information about building components in a structure."
I work daily in Revit, but that’s about the extent of my knowledge.
A little bit of everything.
Building Information Modeling. Models that include technical information beyond standard drawing information.
Somewhat, but definitely not everything.
I am very familiar with what BIM entails.
Quite a lot.
A tool for projects, such as coordination between disciplines, information storage/sharing.
I use it in project planning.
"A normal amount"—BIM management is handled by the BIM coordinator, but I am used to leading the work.
It is used in project planning and is important for alignment during the process, for detecting clashes in documentation. It is beneficial for quality assurance, accessibility, and future use.
Limited, but it is part of many projects I am involved in.

Its meaning tends to vary between assignments. Sometimes, it just means that a 3D model must exist. Other times, it also includes information attached to building components.
I mainly work with calculations and do not draw much, nor am I particularly knowledgeable in the subject. I know that we work in the cloud in Revit on larger projects, but I have little understanding of how it impacts the work. I know who is responsible on the team, so I have someone to turn to.
It is a digital tool for gathering information about a building structure to facilitate coordination within and between disciplines and to avoid unnecessary costs in later stages.

Question 9. If No: Why do you think no client raised the issue?
I think it becomes too expensive to model everything in the smallest detail.
Conservative industry and discipline.
I have been involved in projects where we, as consultants, decide to include a 3D drawing to provide more clarity. I assume that clients feel they do not need to bring up the issue because we consultants make the assessment ourselves as to whether it is needed or not.
Because they have too little knowledge about what a 3D model entails and how it can be used. I believe many are quite locked into using 2D drawings, as they have done for many years, simply to stay in their comfort zone.
Lack of knowledge, time, and commitment to learn.
I think they may not have the awareness or knowledge.
If I were to rephrase the question above: If the client only requested 3D models as documentation, without any drawings, my answer would be no. Today, 3D models are primarily used as a coordination tool between different disciplines. In some cases, contractors require parameter data, such as BIP, BSABw, and CoClass, mainly to facilitate cost calculations. Quantifying at the object level in a 3D model is significantly more efficient than doing it from paper drawings. The reason clients rarely request only 3D models may be that they do not see the benefits of BIM beyond the design and production phases. This is true to some extent, but the greatest benefits arise in the management phase, where the client gains full insight into their facilities.
I work a lot with municipal operations, and they are probably not at the forefront in this area. At least that is my guess.
It is new compared to paper drawings, and clients are likely inexperienced with it. Therefore, they choose something they are more comfortable with instead.
Lack of knowledge in the field. Difficult to see the benefits.

Question 20. What do you need from Norconsult to improve your work with the help of digitalization (knowledge about BIM, digital twins, programs, training, AI, etc.)?
Education in software, development of software usage.
More education is needed.
A clearer strategy from management regarding BIM. Hire a BIM manager, an experienced BIM specialist who sees the bigger picture and the needs.
Increased collaboration and understanding between disciplines.

A more proactive approach to digitalization.
Clear design guidelines on how we can work most efficiently with BIM in projects
Knowledge about BIM and training, but I would say that work experience is what I need the most. Education is basically what I already have.
I need to work more with BIM programs like Revit.
Knowledge about BIM - more education.
Don’t know.
Education.
Education on BIM and especially digital twins, where one can see their use, how they work, and what they can be used for."
Right now, things work fine as they are, but I would like to improve my ability to create families and understand parameters in families better. In the future, it would be interesting to get an overview of how to work without drawings.
Education.
We should invest in AI development. It will increase the quality of deliveries by avoiding simple mistakes and automating repetitive tasks.
I develop templates for Revit and AutoCAD. What I need to increase the use of functionalities is for more people to familiarize themselves with the programs' capabilities and see the value in filling in relevant data.
Time and commitment from management.
Programs and people who are "superusers."
More training, as well as clearer directives from above on how we should/want to work within NOAB.
More education sessions.
More structured mandatory training and permission to allocate time for it. Not everything can be learned solely through projects.
Education.
General information about what tools are available and how they make work easier. Education.
Education in all categories.

Question 21. Is there anything else Norconsult can do to minimize risks and costly mistakes?
Review, more review.
A clearer strategy from management regarding BIM.
Put the team before the individual.
Being too hesitant and backward-looking will become costly in the long run.
Clear design guidelines and templates so that there is no room for misunderstandings.
I know that in the HVAC sector, knowledge and development are needed, for example, improving text annotation in Revit.
Don’t know.
Better servers and connectivity
A major risk with 3D models is that clashes are detected at a millimeter level, but the ability to service the building is overlooked. Dampers and/or valves placed several meters high, covered by ducts or pipe routes. The bigger picture is missed.
Nothing comes to mind at the moment.
Training, competence development.

Project managers should be involved at an early stage to ensure that the correct materials are included as soon as possible. Changing materials later on is a common cause of incorrect materials being included in BIM models.
By taking on development costs before it becomes an industry standard. Otherwise, we risk being late to the game and losing opportunities to win bids.
Not investing in this now will cost money and reduce our competitiveness, as well as result in losing attractive employees who will seek out more progressive employers.
Work as consistently as possible with all processes in all projects.
Coordination and joint review of documents, requiring third-party review. Ensure that the designer has the right conditions and competence for their task.
Knowledge transfer in every project.
Clearer overarching and general review processes and self-checks that maintain the same level across all departments. If this could also be linked to digitalization in some way, that would be great.
Don't know.
Have a well-developed and clear coordination strategy for general consulting assignments. Continue developing staff in BIM.

Question 22. Think freely - How do you think you will work with digitalization and BIM in five years?
BIM is becoming more and more common, and models are becoming increasingly detailed.
I want a BIM department at Norconsult, with a BIM manager. A team that supports and helps each other with tricky BIM-related questions and software. Since the field is so broad, a single BIM coordinator cannot know everything, there should be a team with different competencies. That would be a dream!
Considering that Revit was supposed to take over the market 20 years ago and looking at where it is today, I don’t have high hopes.
Hopefully, it will become a natural part of projects—a new standard in the long run.
I think AI will handle that part, and we will only be responsible for descriptions and reviews.
Right now, I work about 40/60 with Revit. It will probably become more common in future projects.
In models (such as Revit), much of the information required to construct and maintain a building is entered directly into the model.
I believe digitalization and efficiency improvements will continue with more automated tools, but it will be the consultants’ responsibility to optimize and review the overall picture.
It will probably never completely replace drawings on construction sites. However, it will play an increasingly important role throughout the entire construction and management process.
I believe and hope that the HVAC industry will become more digitalized. Right now, 2D drawings are still the standard, so I hope there will be a shift towards 3D.
I think there will be more projects without traditional drawings and that more people will stop using AutoCAD.
It will be replaced by AI.

I believe that BIM combined with AI technology can streamline work such as coordination and reduce timelines, though manual intervention will still be required for verification.
I think there will be much more focus on 3D models rather than 2D drawings. I also think AI will be much more integrated and an obvious assistant in all aspects of modeling.
I hope that AB25 and ABPU25 maintain their strategy regarding digital models. Additionally, I hope Sweden agrees on a standardized way to classify objects. Right now, it's unclear with too many options, such as BH90, SIS BH, BEAst, BIP, CoClass, BSABw, and BSABe.
Hopefully, projects will be mostly drawing-free, including room descriptions and technical specifications in the models.
As a project manager, visualization and clash detection are the most important aspects and will continue to be just as crucial in five years. Being able to visually present change orders or other adjustments to the client can be improved.
Usage will increase.
It will become an absolute prerequisite for working with design and planning. I believe our industry is on the verge of a major leap in digitalization.
I think most people will be working with it in five years.
I am both quite uninterested and uninformed about everything that is already possible today. But I believe we need to speed up internal development to keep up.
We must ensure that development and training keep pace; otherwise, by the time we learn something, new tools will already be available.
Now, I can't think of any way BIM will make calculations easier in the future, but I am not very knowledgeable about the subject.
Probably similar to today… But hopefully, AI development will have made it easier to automate workflows in modeling software so we can spend more time on other tasks.

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

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