FACULTY OF TECHNOLOGY

Collaborative methods in industrial investment projects

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INDUSTRIAL ENGINEERING AND MANAGEMENT

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ABSTRACT

Collaborative methods in industrial investment projects

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Supervisor(s) at the university: Jaakko Kujala, Tommi Pauna, Outi Ruusunen

The objective of this study is to research how collaborative methods can be used to solve challenges in industrial investment projects. The literature review, which focuses on the industrial investment projects and the delivery models, and the empirical data are then combined to find ways to use collaborative delivery models to solve challenges in industrial investment projects. The literature review focuses on following areas: industrial investment projects, project management, different delivery models and challenges in different delivery models. The literature review also presents the collaborative project delivery methods and the benefits of using each method. The empirical part focuses on demonstrating the key challenges that stood out from the interviews, and how the collaborative methods can be used to solve the challenges.

Traditionally, industrial projects and industrial investment projects have been delivered using the design-bid-build, the design-build, or the construction manager at risk -models. Nowadays using collaborative methods, such as the alliance method, have been gaining more popularity in industrial investment projects. The collaborative methods can be used to solve the common challenges in the different phases of industrial investment projects. This study offers a set of suggestions on how to use collaboration more effectively to predict and solve the most common challenges. The outcomes of this study can be used to research the topic further and to use the solutions offered in this study in an actual project setting.

Keywords: industrial investment projects, project delivery methods, project management, collaborative methods

TIIVISTELMÄ

Yhteistoiminnalliset menetelmät teollisuuden investointiprojekteissa

Joel Hautajärvi

Oulun yliopisto, Tuotantotalouden tutkinto-ohjelma

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Työn ohjaajat yliopistolla: Jaakko Kujala, Tommi Pauna, Outi Ruusunen

Tämän työn keskeisimpiä tavoitteita on tutkia, miten yhteistoiminnallisia menetelmiä voidaan hyödyntämään teollisten investointiprojektien yleisimpien haasteiden ratkomiseksi. Työssä yhdistetään kirjallisuuskatsaus ja empiirinen data, ja niiden avulla on tarkoituksena löytää uusia keinoja hyödyntää yhteistoiminnallisia menetelmiä teollisuuden investointiprojektien ongelmien ratkaisemiseksi. Kirjallisuuskatsaus keskittyy seuraaviin aihealueisiin: teollisuuden investointiprojektit, investointiprojektien eri vaiheet, projektinhallinta, projektien toimitusmenetelmät ja haasteet eri toimitusmenetelmissä. Kirjallisuuskatsauksessa esitellään myös yhteistoiminnalliset menetelmät ja eri menetelmien keskeisimmät hyödyt. Empiirisen osan tarkoituksena on mallintaa yleisiä haasteita, joita työn aikana tehdyissä haastatteluissa ilmeni, ja tuoda ilmi yhteistoiminnallisia keinoja, joiden avulla yleisimpiä haasteita voidaan ratkoa.

Perinteisesti teollisuuden investointiprojektien yleisiä toimitusmalleja ovat suunnittele-tarjoa-rakenna-, suunnittele-rakenna- ja construction manager at risk -toimitusmallit, mutta nykyään investointiprojekteissa käytetään enemmän myös yhteistoiminnallisia menetelmiä, kuten allianssimallia. Yhteistoiminnallisten menetelmien avulla voidaan myös ratkaista yleisiä haasteita teollisuuden investointiprojektien eri vaiheissa. Työn tuloksena syntyy erilaisia yhteistoiminnallisiin menetelmiin pohjautuvia ratkaisukeinoja teollisuuden investointiprojekteihin. Työn tuloksia voidaan käyttää aiheen vielä syvempään tutkimukseen ja työn tuloksia voidaan myös hyödyntää ja testata aidossa projektiympäristössä.

Avainsanat: teollisuuden investointiprojektit, projektin toimitusmallit, projektinhallinta, yhteistoiminnalliset menetelmät

FOREWORD

The goal of this thesis is to combine present, how collaborative methods can be used to solve challenges in industrial investment projects. My personal interest in this topic rose from my interest in project management and managing large, complex projects. This thesis was written between April 2022 and September 2022.

I want to thank Merius Oy for helping me to conduct the interviews and find the interviews. I also hope that the data gotten from the interviews helps Merius Oy with their future business activities. I would also like to thank every interviewee who participated in the interview and made it possible to gather the data needed to conduct the research.

Furthermore, I want to thank my supervisors Jaakko Kujala, Tommi Pauna, and Outi Ruusunen at University of Oulu. Your feedback, insights and comments helped me to logically structure and write my thesis. It was a pleasure to work with you and learn from you, as you truly are professionals in the field of project management.

Oulu, 02.09.2022

Joel Hautajärvi
Joel Hautajärvi

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LIST OF ABBREVIATIONS

A/E	Architect/engineer
CMAR	Construction manager at risk
DB	Design-build
DBB	Design-bid-build
EPC	Engineering, procurement, and construction
EPCA	Engineering, procurement, construction, and alliance
EPCM	Engineering, procurement, construction, and management
GMP	Guaranteed maximum price
IPD	Integrated project delivery

1 INTRODUCTION

1.1 Background

In today's world, industrial companies create most of their revenues and assets through projects. The amount of big, complex projects has increased during the last decade in various industries such as the oil industry, the chemical industry, the construction industry, and the power industry. The complexity of projects has increased due to various reasons, such as the scarcity of resources and materials, and the need to spread the costs to a wide enough base to make the project beneficial. As the complexity and size of the project increases, the projects have become more difficult to manage. If the complex projects are poorly managed, the costs may go over the budget, the completion schedule may slip, or the scope of the project may increase too much (Merrow 2011).

Traditional project delivery models include models such as the design-bid-build model, design-build model, construction manager at risk model, and EPC/EPCM models. These models have been very commonly used throughout the history of industrial investment projects. Each of the models have differences between them, and each of the models are used for their own purposes. The traditional project delivery models also have their own challenges, which is why alternative methods, such as collaborative methods, should be researched and used to solve the challenges.

As the projects have gotten more and more complex throughout the years, the need for alternative project delivery methods has increased. Due to the increased complexity, the need for collaborative processes, where people or organizations work together to achieve common goals by sharing resources and knowledge, has increased (Dietrich, Eskerod, Dalcher & Sandhawalia 2010). Collaborative methods, such as the alliance model, integrated project delivery, and project partnering model have been getting more popular because of the increased need for collaboration between then stakeholders in large industrial investment projects. According to Pauna, Lampela, Aaltonen, and Kujala (2021), collaborative project delivery models could be used to solve challenges in complex projects, and in some industries, models such as Alliance already have been used to manage large industrial projects. Different types of contract models have been invented to increase the collaboration between the stakeholders, for example the contractor and the design company.

1.2 Objectives and research questions

This study focuses on how collaborative methods can help solve challenges and challenges in industrial investment projects in various industries. The increasing complexity of the projects has led to companies searching for more ways to handle and prepare for unforeseen challenges and challenges in projects (Bryde, Demir & Sertyesilisik 2013). As the complexity increases, the projects have more different actors that are constantly changing and interacting with each other. These actors can include, for example, the different stakeholders of the project, such as the investor, the supplier, the contractors, and the engineers (Maylor & Whitty 2009). The need for collaboration between the elements has increased, as the project companies need external capabilities to complement their own functions and resources (Davies & Brady, 2000).

The objective of this study is to research if collaborative methods can be used to overcome challenges and to solve challenges in industrial investment projects. The research questions to help fulfil this objective are:

RQ1: What are the key characteristics of industrial investment projects and the different ways to deliver the projects?

RQ2: What are collaborative methods and how are they used in projects?

RQ3: How collaborative methods can be used to solve typical challenges in industrial investment projects?

The first two research questions will be covered in the literature review part of this study. The third part of this study, which focuses on the empirical part and discussion about using collaborative methods to solve different challenges in industrial projects, provides an answer to the third research question. Goal of the literature review is to provide understanding about industrial investment projects, different phases of investment projects and the different ways to deliver industrial investment projects. The literature review will also provide understanding about collaborative methods in general, different types of collaborative methods and how these methods are used in project environments. The empirical part of this study focuses on researching ways to use collaborative methods in different types of investment projects to solve challenges and challenges. The goal of the empirical part is to research how collaborative methods can be used to solve

challenges in different phases of investment projects. The study also covers if there are differences in challenges in different types of investment projects, and if the collaborative approach needs to be used differently in different types of projects.

1.3 Research process and thesis structure

This thesis includes the introduction, the theoretical part, the empirical part, the discussion, and the conclusion. Aim of the introduction is to provide the reader understanding about the research topic and why the topic should be researched. The theoretical part of the thesis is the literature review, and it focuses on providing an understanding about industrial investment projects, traditional delivery, and collaborative project methods. The literature review begins with presenting the characteristics of industrial investment projects, and continues with presenting the traditional project delivery methods, and the challenges related to traditional project delivery methods. The last part of the literature review presents the different collaborative project delivery methods, the challenges of the collaborative methods, and the benefits of each method. The empirical part focuses analyzing the data gathered from the survey and the semi-structured interviews to find out what different types of challenges there are in industrial investment projects. Next part of the thesis, the discussion, focuses on analyzing the how the collaborative methods can be used to solve the different types of challenges in different phases of the industrial investment projects. The last part of the thesis is the conclusion, which includes the key results of this study, managerial implications, future research ideas, and the limitations of the research. The structure of the thesis is presented in the picture below:

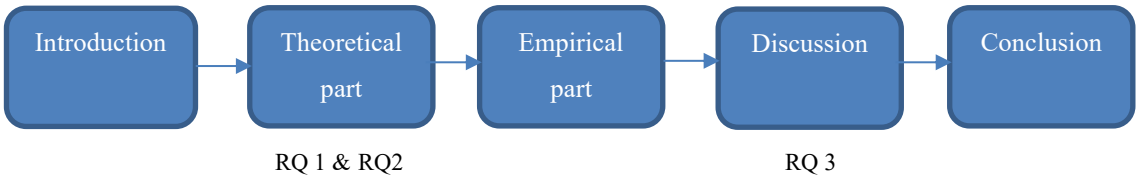

Figure 1. Structure of the thesis

2 LITERATURE REVIEW

2.1 Industrial investment projects

2.1.1 Industrial investment project management

A project is a set of tasks that are done to produce a goal or a product. Every project aims to deliver a unique product, service, or a result, even though projects often have repetitive elements in some deliverables. Projects are temporary, meaning that they always have a definite start and end (Project Management institute 2013). Project management means applying the necessary knowledge, skills, and expertise to the project activities to achieve the set goals (Project Management Institute 2013). Project managers are responsible of meeting the project scope, schedule, and budget. They also have to facilitate the process of handling different project stakeholders to meet their needs and expectations (Schwalbe 2009).

In today's world, projects are a vital part of any business and industrial organizations. Projects can be seen as the drivers of strategic goals for every complex organization. Industrial investment projects are often complex projects that demand disciplined management, and the best ways to manage these projects has been a key research topic for a long time (Tonchia 2008). In industrial investment projects, such as construction projects, project management requires knowledge of project management, and knowledge about the more technical side of the project, which includes the design process and the construction process (Hendrickson & Au 2000).

The project management plays a key role in modern investment projects. According to Levy (2018), the project management can be divided in to four different components: construction engineering, management of the construction process, human resource management, and financial management. Although Levy (2018) applies these components to construction projects, the same components can be applied to all investment projects because the same project management principles remain even though some elements, such as technology or institutional agreements may differ (Hendrickson & Au 2000).

First component of Levy's (2018) four components of project management is construction engineering. Construction engineering means that the project manager must

properly manage the materials, components, systems, and equipment used in the project. The project manager also must ensure that the correct technology is used in the construction phase of the project to effectively utilize the resources of the project. The second component is the process management. The process management includes all things related to optimizing the scheduling of the project and controlling the flow of labor. Third component is human resources management. Human resources management means optimizing the efficiency of the employees while keeping them satisfied and the work environment harmonious. Human resources management is a big factor in successful projects, because skilled employees and managers are hard to find. The final component is financial management. Investment projects are often financially risky projects, and the short-term profits are low. The project manager must be able to properly control the costs, cash flows and project funding to make the project as profitable as possible (Levy 2018).

The four project management components all affect the outcome of the project and are mostly visible to both the internal and external stakeholders of the project (Levy 2018). Levy (2018) also lists seven criteria for a successful project from the project management perspective:

- The project was completed according to the schedule
- The costs of the project remained within the agreed budget
- The project was completed with the expected quality
- There were no unsolved challenges in the project and no outstanding claims
- The relationship between the owner, contractor and designer remained professional
- The contractor maintained a good, mutually beneficial relationship with all subcontractors and vendors
- The client and the contractor remained a good relationship

2.1.2 Phases of an industrial investment project

Industrial investment projects can be divided into different phases. In industrial investment projects, these phases can be, for example the investment preparation phase, project execution phase, and the operations phase (Aaltonen & Kujala 2010). According to Osipova (2007), construction projects are traditionally divided into four main phases, which are the programme phase, planning, procurement, and production. Even though the phases are named differently by different authors and literature, they are very similar to

each other, and the projects follow the same pattern. For clarity, the phases used in this study will be investment preparation phase, planning phase, project execution phase and the operations phase.

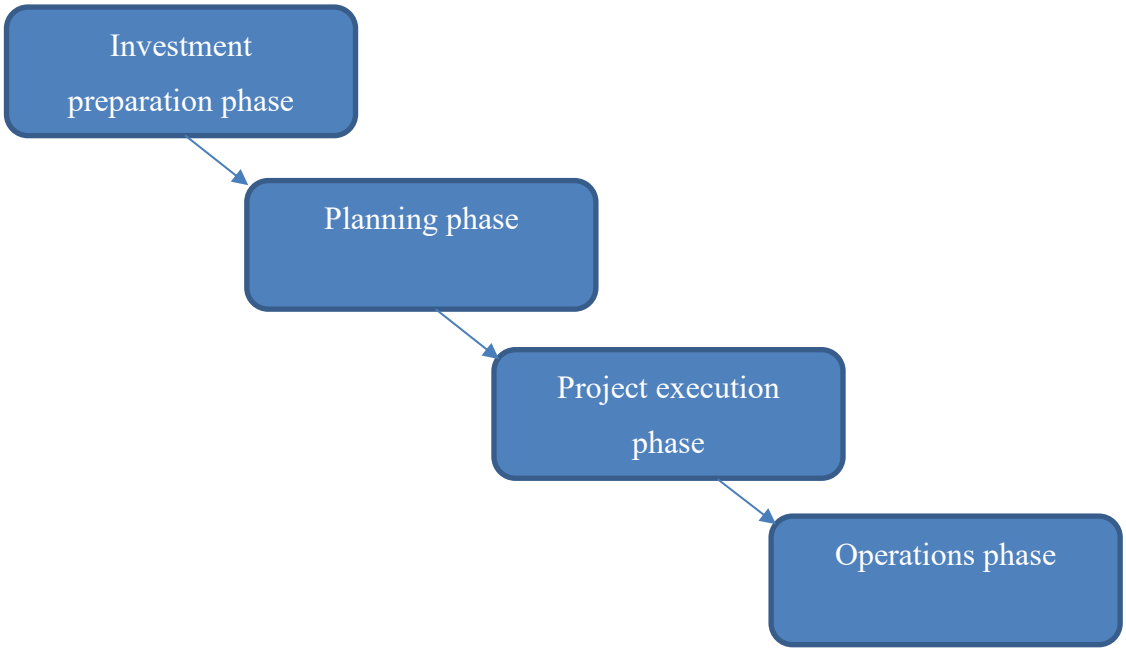

Figure 2. Phases of an industrial investment project (Adapted from Pinto & Prescott 1988)

The first phase of the project is the investment preparation phase, where the main decisions related to the feasibility of the project are made (Aaltonen & Kujala 2010). The investment preparation phase includes two main studies, the pre-feasibility study, and the feasibility study. The pre-feasibility study focuses on analyzing previous research on the topic, and it provides a basis for analyzing if it is justified to proceed with the selected investment project (Jovanovic, Sobajic & Jovanovic 2014). When the pre-feasibility study is done, the project can proceed to the feasibility study. The feasibility study is a strategic study that provides the most important "go/no-go" decision for the project (Aaltonen & Kujala 2010). The feasibility study provides the basic elements for analyzing and evaluating the possibilities of the project and justification on if the project should be implemented or not (Jovanovic et al. 2014).

After the investment preparation phase is done and the investment project is justified, the next phase is the planning phase of the project. Because investment projects always have a unique goal, the planning of a project is not simple and has to be done carefully for the project to be successful (Andersen 1996). According to Tonchia (2008), the planning

process includes three main variables: budgeting, scheduling and resource allocation. Planning the budget of the project includes planning all the expenses of the project and planning how to allocate the expenses. Budget planning also includes preparing for possible costs in later stages of the project. Planning the schedule includes planning the start and finish date for all the activities that are included in the WBS (work breakdown structure) of the project. Resource planning means planning the allocation of all the available resources to the different tasks in the project (Tonchia 2008). The designer of the project is often very involved in the planning phase of the project and the design activities include, for example, creating the WBS for the project. The WBS conducted by the designer together with the project manager The WBS is an essential part of the project's lifecycle, and it is used to make complex project more manageable. The WBS breaks down the project to the tasks and elements to establish a clearer framework for the managers to effectively manage the scope, schedule, and budget of the project (Devi & Reddy 2012).

The execution phase of the project is mainly the selected contractor's responsibility (Jergeas & Cooke 1997). From the project management perspective, the main goal of the execution phase is to reach the project goals within the agreed scope, schedule, and budget, and to deal with changes and risks in the project. The project manager also has to keep all stakeholders of the project informed of the project status. (DeFuria 2009) These tasks are most often carried out by the contractor's project management. In the execution phase, the client does not have that much direct involvement in the project. The client can be involved in for example ensuring the build quality and making sure that the communication flows in all directions, but the contractor is mainly responsible of ensuring that the construction phase proceeds according to the contract made by the client and the contractor. (CIOB 2010)

In the project execution phase, the work package is done according to the contract between the client and the contractor. There are different delivery models that the client can choose form and the client selects the contractor based on the selected model. During the execution phase, the contractor delivers the work according to the documents that were made during the planning phase. The contractor must follow the contract and provide the client a documentation about the work and all the materials and resources used during the execution phase. Sometimes, the client selects to use a construction manager that acts as a consultant for the execution phase. The construction manager's

role is to enable the execution process to be as smooth and effective as possible. The construction manager also supervises and co-ordinates the contractor's work. The contractor can use subcontractors during the execution phase. Subcontractors are usually used for specific expertise, for example pipe installations or lift installations. (CIOB 2010)

The project operations phase includes all activities after the execution phase. According to Dilawer (2016), the project operations phase can include, for example, handover to production or other stakeholders. The handover must be done in a controlled manner for the operations phase to succeed. The team responsible for the project delivery should allocate enough resources to the operations phase and the client should allocate enough people to ensure that the handover from one party to another is smooth. For example, trainings should be done properly to avoid unnecessary risks and damages after the delivery of the project. (Dilawer 2016)

2.2 Traditional project delivery methods

2.2.1 Design-bid-build model

Design-bid-build (DBB) model has throughout the history been the dominant delivery model in industrial projects. It has always been very common especially in the construction industry, where professionals were using it in almost all projects all the way until the 1990s. (Friedlander 1998)

In the DBB model, the owner makes separate contracts, one with the party or parties that are responsible for the project design, and one with the contractors that are responsible for the construction (Ahmed & El-Sayegh 2020). In the DBB delivery method, the owner first buys the complete design service from the consultant or the designer, and then based on the design documents, selects a contractor or contractors to complete the construction (Touran et al. 2009).

Figure 1 shows the relationship between the owner and the other parties of the project in the DBB model. The project owner first makes a contract with the architect/engineer (A/E) responsible for the design. The A/E is also responsible for providing all detailed construction instructions, specifications and supporting documents. Once the design is complete, the owner gathers the design documents to assemble the bidding documents for

the contractors. All eligible contractors are then invited to submit their bids, and the owner awards the complete construction contract to the lowest bid. (ACCM 2017) According to Ahmed and El-Sayegh (2020), the DBB model is often associated with the single-fixed price or a lump-sum contract, where the contractor performs a specific task for a specific price. The design and construction phases of the project are distinct, and there is no contract between the A/E and the contractor (ACCM 2017).

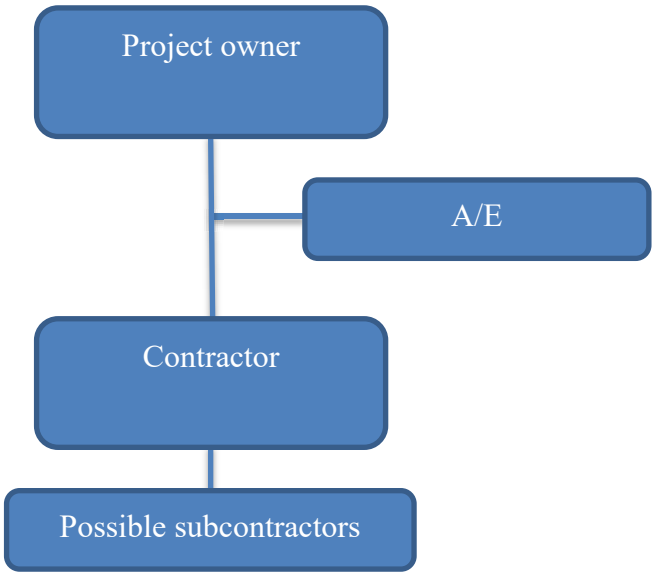

Figure 3. Relationships in the DBB model (Adapted from ACCM 2017)

2.2.2 Design-build model

Design-build (DB) model is an another very popular model in the construction industry. In the DB model, the defining characteristic is that only one party is responsible of both design and construction, which helps to diminish the gap created by the fragmentation in the DBB model, where the design and construction is fragmented between multiple parties. Therefore, the DB model can be seen as a bit more collaborative model than the DBB model. (Bausman & Carpenter 2016)

The DB model is a similar model than the DBB model in a way that the owner creates a contract between the owner and the party responsible of the design and construction. In the DBB model there are multiple contracts between the parties. However, in the DB model, the contract is only between the owner and the design-build company. The design-build company is completely responsible of both the design and the build. As seen in figure 2, the DB model allows for a simpler communication, where the communication flows only between two parties instead of more. (Gransberg, Koch & Molenaar 2008)

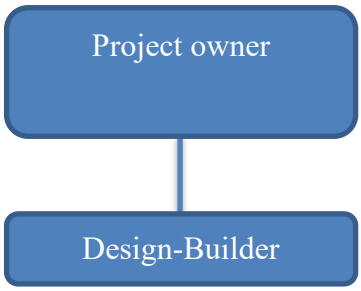

Figure 4. Relationships in the DB model (Adapted from Gransberg et al. 2008)

In the DB model, the procurement phase can have a very critical impact on the project outcome, since it defines the design-builder of the project, which is a major player in the DB delivery model. If the design-builder is not selected properly, it can result in many challenges in all phases of the project and the quality of the whole project can suffer greatly. However, creating a proper procurement team and selecting the right design-builder that can align their processes with the DB delivery method can be a very complex process that causes difficulties to the project owner. (El Wardani 2006) Some procurement methods that are commonly used in the DB model are sole source selection, qualifications-based selection, best value selection and low-bid selection (S, Messner & Hoffman 2006).

2.2.3 Construction manager at risk model

Construction manager at risk model (CMAR) is a project delivery model where the whole project team is included in the planning phase of the project, instead of just the owner planning the project before selecting the parties responsible for the design and construction. In the CMAR model, the project team consists of the owner, the designer, and the at-risk construction manager. The aim of the CMAR model is to reduce and minimize risks, increase constructability, and enable concurrent actions in the design and construction processes by including all the parties to the project planning process. (Gransberg & Shane 2010)

In the CMAR model, the at-risk manager is responsible of delivering the project within a guaranteed maximum price (GMP). The GMP is based on the planning documents conducted by the project team in the planning process. The at-risk manager is often not part of the construction team but can help in the construction process if the process fits the expertise of the at-risk manager. The manager is also responsible of managing the

costs of the project because the costs that exceed the GMP are liability of the at-risk manager. (Campbell County 2014)

2.2.4 EPC & EPCM Models

Engineering, procurement, and construction (EPC), and engineering, procurement, construction and management (EPCM) are project delivery methods, where the owner creates a contract with a contractor, who is then responsible for either the delivering the complete project or providing project management and coordination services. (Douglas 2016; Loots & Henchie 2007) Douglas (2016) writes that EPC model is often selected because of the possibility of having an integrated project team across the whole project, removing the usual barriers between the different project phases. EPCM contracts are selected to minimize schedule changes when the project scope is unclear or the project includes risks related to, for example, new technologies or environmental issues (Douglas 2016).

According to Loots & Henchie (2007), the main difference between EPC and EPCM models is that in the EPC model, the contractor is responsible for delivering the complete project, and in the EPCM model, the contractor provides design services, procurement services and project management services and project coordination for the owner. The table below exhibits the main characteristics related to financing, scheduling and performance of the EPC and EPCM models.

	EPC	EPCM
Project Financing and costs	Often a fixed price lump sum contract that is paid before the project begins. Contractor is responsible for the project cost risks.	Combination of down payments and accounts of credit from the owner to suppliers. The owner is responsible for the project cost risks.
Performance risk	EPC contractor is responsible for the risks related to the project delivery	Risks are shared and risk-sharing is indistinct. Owner can hire a project manager to set expectations.

Project schedule	A single contractor provides an easy way to measure the accuracy of the schedule through an integrated set of tools. Concurrent engineering and construction enables a more succesful scheduling.	The amount of tools varies, and if accurate measuring is expected, the project owner or the project manager is responsible for the tools. Construction contracts are often made only after the design process.

Table 1: Characteristics related to financing, schedule and performance in EPC and EPCM models (Douglas 2016)

2.3 Challenges in traditional project delivery models

Although the traditional project delivery methods (DBB, DB and CMR) have been used for a long time, they have common challenges that could have negative effects on construction projects (Kortenko, Koskela, Tzotrtzopoulos & Hasgsheno 2021). The different methods have different challenges that are related to different areas, such as communication or separated stakeholders in the project.

2.3.1 Design Bid Build model

In the DBB model, the scheduling of the project is often a challenge. One of the challenges in scheduling is compressing the project schedule if needed (Touran et al. 2009). According to Touran et al. (2009) the DBB model does not allow the project to be compressed to a shorter schedule when needed because the project is very sequential and rescheduling the project would require too much coordination. Another challenge in the schedule is that DBB model, by definition, separates the designers and contractors in the project, which means that the contractor cannot be involved in the design process. The separation can cause heavy issues in the schedule of the project. If the design is done poorly, the project could be impossible to construct, which leads to rework in design. The separation can also cause conflicts between the contractor and the designer because the contractor wants the designer to redesign the project and the designer wants the contractor to handle the flaws in the design. (Kortenko et al. 2021)

In the DBB model, the procurement process is often based on the lowest bid wins mentality. According to the interviews conducted by Kortenko et al. (2021), “the lowest bid win” mentality does not necessarily mean cost savings in the project. Because of the siloed system in DBB, the initial cost may not be the final cost, but instead the costs can rise during the project because of various reasons. These reasons include changing the design or the design team during the project, unqualified contractors that do not have enough expertise, and focusing on the short-term costs instead of long-term costs. (Kortenko et al. 2021)

According to Kortenko et al. (2021), the third big challenge with the DBB model is the contractual separation. The separate contracts between the client and the designer, and the client and the contractor, lead to separated risk management and the different parties in the project tend to shift the risks to another parties. Having separate contracts also leads to each company having their own goal in the project, and when all companies focus on their own goals, the companies do not share knowledge with each other. In the interviews conducted by Kortenko et al. (2021) there is a common perception that when all parties pursue their own goals, there is no shared understanding about the common goals between the parties. In these types of situations, no one is focusing on the big picture and the project as whole, but instead everyone seeks for their own economic benefits. This can create conflicts between the parties in the project, as everyone tries to shift their risks to other parties and minimize costs to gain benefits. This can also create a hostile environment between the people of different organizations in the project. (Kortenko et al. 2021)

2.3.2 Design Build model

From the perspective of the project owner, the DB model is a simpler model than the DBB model because there are less stakeholders in the project. The DB model can also save time because the same firm provides both the design and the construction. Still, there are challenges in the DB model, for both the owner and the stakeholder responsible for the design and construction. (Fernandez-Solis & Chugh 2018)

According to Fernandez-Solis and Chugh (2018), the disadvantage in DB compared to other delivery models is costs. In the DB model, there is a big risk that the costs escalate from the initial agreement between the owner and the DB firm. The price contract is made before the planning phase begins, and because of unforeseen events and challenges, the

costs may rise during the project. The rising costs pose a risk for both the DB firm and the owner. While the DB firm is responsible for the rising costs, the risk for the owner is that the project could be delayed or even left unfinished if the DB firm runs out of money and the owner cannot provide financial support for the DB firm. (Fernandez-Solis & Chugh 2018)

From the owner's perspective, another challenge in the DB build is the lack of control in the project. In other project delivery models, the designer of the project can work as a supervisor in the construction phase, ensuring that the construction is done according to the design. In the DB model, the design and the construction are allocated to one single provider, which means that there are no stakeholders ensuring the quality of the design and the construction. If the selected DB firm is not competent enough, the project quality may suffer, which is a big risk for the owner. Tenah (2000) According to Ling and Poh (2008), there is also a risk that the DB firm's design quality is worse than the owner's standards, which could harm the planning and delay the construction. To mitigate this risk, the owner could of course use, for example, external consulting firm to supervise the design and construction phase but using external resources can also increase the project (Tenah 2000).

The DB model has risks for the DB firm. Since the DB firm is solely responsible for the design and construction, there is no other stakeholder sharing the risks included in the processes. The DB firm is solely responsible of the rising costs and possible delays in the project. In the DB model, there is also an increased risk of nonpayment from the owner, especially in the early planning and design phase, where the owner has not fully committed to the project. (Twomey 1989, as cited by Mouritsen 1993) Another risk is related to insurances; in some cases, the available insurances do not fully meet the needs of the DB firm in the DB model (Tenah 2000).

2.3.3 Construction manager at risk model

According to Keen and Fish (2012) the CMAR model provides a lot of benefits such as faster completion of projects and better control of the schedule compared to the DBB and DB models. The CMAR model involves the construction manager in the preconstruction phase of the project, which helps to minimize the risks in the planning and early construction phases (Bilbo, Bigelow, Escamilla & Lockwood 2015). Still, there are some disadvantages and challenges in the CMAR model.

According to Touran et al. (2009), the risk management could be a challenge in the CMAR model. Although having an experienced construction manager in the project, the risk allocation could be difficult because the number of parties involved in the project increases. The GMP should reduce the owner's risks in the project, but if the owner and the construction manager do not agree on the GMP in time, there is a big risk that the project gets delayed, and the owner will suffer from the delay. (Touran et al. 2009)

Industrial investment projects often require some creativity because of the unique outcome of the project. According to Bilbo et al. (2015), the CMAR model does not allow for a lot of creativity because the structure of the project is agreed in the early phases of the project. The contract made between the owner and the construction manager requires the construction manager to work according to the preconditions set by the owner, which makes it hard to make changes during the later phases of the project such as the construction phase. (Bilbo et al. 2015)

2.3.4 EPC & EPCM models

According to Hansen (2015), the EPC and EPCM models have been gaining a lot of popularity among the traditional project delivery methods. Yet they still have their own challenges. Hansen (2015) lists the most common challenges with the EPC and EPCM models:

- Loss of control for the owner
- Managing costs is difficult
- Models require strong commitment from all parties
- Loss of control over vendors and subcontractors
- Limited transparency to costs and risks
- Less control over procurement actions such as tendering

2.4 Synthesis of traditional project delivery methods

The traditional project delivery methods have similar features but are all unique in different ways. Each of the delivery methods have their own use cases and challenges. The table below exhibits the most common features and challenges of each traditional delivery method.

Delivery method	Main Features	Main challenges
DBB	• Owner has separate contracts for the contractor and A/E firm • A/E firm provides the detailed design, and the contractor is responsible for the construction	• Sequential process and separated project actors creates risks for the scheduling • Separate A/E and construction may cause conflicts between the actors • Lowest bid wins -system may cause additional costs later in the project • Separate contracts can cause separate goals for the different actors
DB	• Very similar to DBB • The owner makes a single contract with a company that is responsible for both the design and the construction	• Poorly chosen design-build firm can cause challenges to the owner • Rising costs can potentially stop the entire project • Lack of control for the owner • For the DB company, the main risk is nonpayment from the owner
CMAR	• The whole project team is included in the planning • The at-risk manager is responsible of delivering the project by the GMP that is based on the planning documents	• Increased amount of parties may make risk allocation more difficult • If the GMP agreement is not done on time, the project can be delayed • CMAR does not allow for a lot of creativity because the project structure is decided early
EPC & EPCM	• The owner makes a contract with a company that is then responsible for delivering the complete project or project management services • EPC can be seen as similar to DB and EPCM as similar to CMAR	• Loss of control for the owner • Lack of transparency • Requires strong commitment • Limited risk control

Table 2. Main features and challenges of traditional project delivery models

2.5 Collaborative project delivery methods

2.5.1 Alliance

Generally, the concept of alliance refers to an agreement or association between two or more actors, and the aim of the alliance is to integrate the actors' operations (Lahdenperä 2009). In industrial projects, alliancing is a form of project partnering where the project owner forms a team or an alliance with one or more of the stakeholders of the project, such as the contractors, designers, constructors, or other service providers (Ross 2003). According to Walker, Hampson, and Peters (2002), in project alliancing, the project is usually developed with a trustworthy team, that consists of the owner and other skilled stakeholders. The responsibility in the joint organization is shared in a way that both the positive and the negative risks are shared according to the contract between the actors (Lahdenperä 2009).

The alliance project delivery method can be described by two types of features: structural and collaborative. The structural features are hard and absolute, meaning that the project cannot be implemented without these features. The collaborative features are soft features, but they are just as important to the alliance method than the structural features, as they are also characteristics and preconditions for a working project alliance. According to Lahdenperä (2009), the structural features are joint agreement, joint organization and risk sharing, and the collaborative features are trust, commitment, and cooperation. (Lahdenperä 2009)

The structural features are based on contracts between the actors of the alliance (Lahdenperä 2009). The joint agreement means that some of the tasks that are traditionally performed by the owner, such as promotion, are performed by the joint organization (Walker et al. 2002). According to Walker et al. (2002), the joint organization is also responsible of project planning, implementation and tasks related to them. Instead of having multiple bilateral contracts, the organization enters a single joint multi-actor contract. The joint organization feature means that the organization includes people from all the partner organizations, and the decisions related to the project are done together with all parties (Lahdenperä 2009). The costs of the project include all the costs of the items and people of the different parties of the joint organization, and for example the project budget is shared between the parties (Walker et al. 2002). The third structural feature is risk sharing, which means that the alliance parties share both the positive and

negative risks of the project. The reward of each single party is based on the overall success of the project, instead of the performance of the party. For the risk sharing to function properly, transparent monitoring of costs and performance is needed. (Lahdenperä 2009)

The collaborative features are related to the nature of the collaboration in project alliances. Trust is a collaborative feature, that is a central element in the project alliance. Trust is needed for the alliance parties to be open and transparent about their performance and tasks. Trust takes time to build, which is why different types of trust-building activities, such as workshops, are needed. Another collaborative feature is commitment. In alliance, the goals, challenges, and continuous development are internalized, which is why the actors of the alliance must be committed to the project. The commitment can also be built by having appropriate organizational structures. The commitment helps build trust in the alliance. The third collaborative feature is cooperation. For the alliance to function properly and effectively, the parties must work together to improve preconditions for effective operations and exchange information actively to reach the set goals and targets. Communication can also be improved by using common information systems and decision-making protocols. (Lahdenperä 2009)

According to Hietajärvi, Aaltonen & Haapasalo (2017), the alliance project can be divided in to three main phases, which are the formation phase, development phase, and post-formation phase. During the formation phase, the stakeholders of the project build the required knowledge to form the alliance team. The stakeholders also organize workshops to create a common core knowledge for the project. (Hietajärvi et al. 2017) The trust between the stakeholders in the formation phase may be low since the stakeholders are not yet fully committed to each other, and the decisions are made based on the limited information available (Davis & Love 2011). In the end of the formation phase, the alliance should be formed, and the common goals should be agreed upon. The goal of the development phase is to collectively train the collaborative skills. This includes, for example, defining the governance model for the project, building the collaborative working culture, managing uncertainties, learning to use common tools, and defining organizational agreements. The last phase of the project is the post-formation phase. The post-formation phase includes implementing the project at team level, developing the network and collaborative culture, adapting to the new tools, and managing the project resources. (Hietajärvi et al. 2017)

If the alliance model is implemented properly, the model offers benefits to both the project owner and the different stakeholders. According to Ross (2003), the key benefits for the owner are:

- On time delivery of the projects
- Better and more effective stakeholder management
- Better management of health & safety
- Transfer of skills, skills, and professional development for the project staff
- Enhanced reputation for all stakeholders

According to Ross (2003), the key benefits for the non-owner stakeholders include:

- Potential for very good returns with minimized risks
- Strengthening the relationship with the owner
- Better understanding about the project delivery from all perspectives
- Increase in general project management and communication skills for the employees
- Opportunity to use the gained knowledge to improve the performance of the organization
- Better reputation

2.5.2 Integrated Project Delivery

According to AIA National and AIA California Council (2007), integrated project delivery (IPD) is a project delivery method where the people, systems, business structures, and practices are integrated into the process to fully harness their potential and to deliver optimized project results, increase value to all parties of the project, reduce waste and increase efficiency through all phases of the project. The NASFA, COAA, APPA, AGC, AIA (2010) defines IPD as a philosophy, that occurs when integrated practices are applied to traditional project delivery methods. According to Mesa, Molenaar, and Alarcon (2019), IPD is an innovative approach that has been rapidly gaining popularity, especially in the construction and design industries. One of the main goals of IPD is to have highly effective collaboration among the owner and other parties, such as the designer and contractors (AIA National & AIA California Council 2007).

The core principle of IPD is that it is built on collaboration and trust between the parties. According to AIA National and AIA California Council (2007), when the collaboration is effective and trust-based, the focus of the different parties is on the overall goal of the project instead of the individual performance. To achieve the benefits of the IPD method, the parties must embrace and live by the set of principles related to the IPD method. These principles can be found in the table below. (AIA National & AIA California Council 2007)

Principle	**Definition**
Mutual respect and trust	All participants must understand the importance of collaboration and work as a team to reach common goals.
Mutual benefit and reward	All participants benefit from IPD, and the compensation structures reward early involvement. The rewards are based on common project goals instead of individual goals.
Collaborative innovation and decision making	Ideas are freely shared among the participants. Key decisions are made together with all the participants.
Early involvement of key participants	The key players are involved as early as possible. The combined knowledge is the most powerful in the early stages of the project when the decisions have the biggest effect.
Early goal definition	The goals are set early and agreed by all participants. All participants must provide insight on the shared project goals.
Intensified planning	Increased effort in planning results in greater efficiency and savings during the later phases of the project. Improved design results in

	easier and more streamlined construction process.
Open communication	Communication between the participants must be open, direct, and honest to achieve the greatest efficiency. Responsibilities are clearly defined. No-blame culture allows for challenges and conflicts to be solved quickly and efficiently.
Appropriate technology	The best available technology should be used, and the technology should be defined early. Data must be exchanged openly, as transparent data structures are essential for the IPD method.
Organization and leadership	The project team is an organization itself, and all members of the team must be committed to the common goals. The leadership is taken by the part that is most capable in each specific phase. The roles must be clearly defined to increase efficiency.

Table 3. Principles of the Integrated Project Delivery (AIA National & AIA California Council 2007)

2.5.3 Project Partnering

Project Partnering is one of the oldest collaborative delivery methods, and it was invented and made popular in the US in the 1980s (Larson 2009). However, even today Project partnering remains a complex concept with no clear definition. Unlike other methods such as the Alliance method, Project partnering is more like a framework for delivering projects in a collaborative way (Børve et al. 2017). According to Walker and Lloyd-Walker (2015), project partnering is a concept or a framework for increasing the value delivered throughout the whole project. Instead of being a completely new way to collaboratively deliver projects, project partnering was originally a way to add collaborative elements to a traditional project setting (Lahdenperä 2017). Trust and cooperation have always been the core philosophies of project partnering, and in the early

days of project partnering, important tools included decision-making ladders, partnering charters, and continuous feedback/evaluation to improve the cooperation between the different project parties (Lahdenperä 2012). Lahdenperä (2012) writes that project partnering can be seen as a project-by-project version of a more long-term model of partnering, strategic partnering. Strategic partnering is used in a series of projects, while project partnering adopts similar ideas in a single project level.

The key elements of project partnering include a workshop between all the parties, where the parties decide the main roles of the project. The workshop is organized by a neutral party and the goal of the workshop is to decide and document a common vision, goals, and ways of working in the project. Another aim of the workshop is to make a decision tree that includes the methods of solving possible challenges. In project partnering, the problem-solving methods are often preventive, meaning that the goal is to solve the challenges as soon as they arise. (Lahdenperä 2017)

In project partnering, the performance of the project is evaluated continuously. The goal of the evaluation is to find possible performance issues and to solve those issues to continuously improve the performance of all project parties. In project partnering projects, good performance is rewarded and celebrated, so that every party commits to the common goal and performs their individual tasks the best they can. (Lahdenperä 2017)

2.5.4 EPCA Model

Engineering, procurement, construction, and alliance model is a project delivery model that aims to enhance the project performance by combining the traditional EPC model and collaborative project methodologies. EPCA includes process model with a set of guidelines, so that EPCA can be tailored based on every industrial project's needs. The potential benefits of the EPCA model are early integration of all project stakeholders, common vision and fast decision making and better predictability and risk management. (Kujala et al. 2020)

The first phase of an EPCA project is the selection of the core team. The owner selects the core team based on competition of different teams. After the team is selected, a multiparty contract is made between the actors of the core team. The contract includes, for example, requirement to work collaboratively. In the early stages of the project, the owner also starts the technical development of the project. The core team is also included

in the development, and the team collaboratively form the key result areas for the project. The core team then continues the development to improve the original plans. (Kujala et al. 2020)

In the EPCA model, the decisions related to initial scope, schedule and costs of the project are made by the project owner. The decisions are then developed and revised by the core team. During the project, the continuous decision-making is done by the project team and the cross-functional groups. In case of an unsolved conflict, the decision is made according to the contract between the stakeholders. (Kujala et al. 2020)

The reward system in the EPCA model works in a way that some of the project costs savings are shared to the project team parties if the project is completed successfully. Individual bonuses are also shared to the parties when the individual key targets are reached. The bonus system gives the core team member incentives to succeed. If the project fails, the team members must pay liquidated, process or warranty damages. The damages have a maximum cap based on the contract between the parties. (Kujala et al. 2020)

2.5.5 Challenges in collaborative project delivery methods

Although the collaborative methods offer benefits, there are challenges in implementing the collaborative methods to industrial investment projects. According to Saukko, Aaltonen, and Haapasalo (2020), these challenges can emerge in different project phases.

According to Saukko et al. (2020), the owners may not have enough knowledge about the collaborative practices when deciding between the delivery models. The project staff may not be skilled enough to use the collaborative practices, which is why the investor may not want to deliver the project using the collaborative methods (Saukko et al. 2020).

The decision-making process can be a common challenge. When using the collaborative methods, the owners sometimes tend to do decisions independently, and not use the benefits of collaborative decision making (Saukko et al. 2020). According to Saukko et al. (2020) leads to a situation, where the organizations maintain their own culture, and focus on their own goals, rather than committing to the common project goal. Pauna et al. (2021) also write that not committing to the common goal can be a challenge in implementing the collaborative methods. Also, according to Pauna et al. (2021),

collaboratively deciding between the resources, such as time and materials, can be challenging.

Monitoring the project and coordination can be a challenge in collaborative projects (Pauna et al. 2021). Especially in the construction or implementation phase of the project, coordinating the contractors and subcontractors is challenging, due to the issue that the stakeholders may not be experienced enough in using the collaborative methods (Pauna et al. 2021; Saukko et al. 2020).

According to Saukko et al. (2020), the challenges in collaboration can emerge in different phases of the project, but the main challenges are related to the first phases of the projects. According to Pauna et al. (2021), the challenges can be actor or stakeholder specific. Therefore, it when selecting between the collaborative methods, Pauna et al. (2021) suggest that the project team should carefully consider, which collaborative practices should be used in which phase of the project.

2.6 Synthesis of collaborative project delivery methods

Collaborative methods offer various tools and ideas to deliver projects in more effective ways. Each of the collaborative methods are unique, but they share common principles, such as early integration of different actors and using collaborative approaches to make decisions and solve challenges. The table below exhibits features of each collaborative method and the benefits of using the method.

Collaborative method	**Key Features**	**Key benefits**
Project Alliance	• Project owner forms a team, or an alliance based on a joint contract between the actors • Structural (contract based) and collaborative (soft) features • Project can be divided to different phases where the alliance is formed and implemented	• Early integration • Easier stakeholder management • Transfer of skills between the parties • Risk sharing and minimizing • Better understanding and involvement in the project for all parties

IPD	• People, systems, business structures, and practices are integrated into the process • Built on collaboration and trust between the parties • Based on several collaborative principles that each actor must act by in the project	• Enables a mutual goal mindset • Offers mutual benefits instead of individual rewards • Enhances collaborative decision making • Improves transparency • Common technology improves communication • Improves no-blame culture
Project Partnering	• Framework for delivering projects in a collaborative way • Based on trust and cooperation • Common tools include decision-making ladders, partnering charts and continuous feedback • Often includes a workshop to implement the collaboration and to define the cooperation • Performance is continuously measured	• Provides a common framework to implement collaborative methods • Provides an easier way to implement long-term partnering in a single-project level • Easy way to start adopting collaborative methods • Rewarding is done in a way that every party commits to the common goals
EPCA	• Combines the EPC model and collaborative methods • Includes a process model with guidelines – can be tailored to each project • The EPCA guideline includes different phases that can be followed to deliver the project	• Provides guidelines to improve the performance of the traditional EPC project delivery • Can be tailored to every project • Improves early integration • Better risk management • Better predictability • The key areas of the project are decided collaboratively

Table 4. Synthesis of collaborative project delivery methods

3 EMPIRICAL STUDY

3.1 Description of research process

This study was done in a collaboration with a company that provides design, consulting, and software services to industrial companies. The case company aims to improve industrial projects by improving the collaborative elements in the projects and by improving the technology used in industrial projects. The company provides services for industrial projects in many different industries.

The research was conducted by doing semi-structured interviews. The aim of the interviews was to research different types of challenges in different phases of industrial investment projects. The interview questions and the interviewees were chosen together with the case company. The interviewees were chosen from different industrial companies. To gain an unbiased and broad perspective of industrial investment projects, project types, and common challenges, the interviewees were chosen from various positions from various companies. The different positions were:

- Upper management
- Middle management/project management
- Specialist
- Buyer
- Other

The different types of companies were:

- Owner of the project
- Contractor
- Design/engineering company
- Other

3.2 Data collection

The data was collected via a semi-structured interview, which consisted of 25 questions. The questions were split two sections; overall questions related to industrial investment projects and questions related to different phases of industrial investment projects. The questions of first phase of the interview are presented in the following table.

Question	Answer options
What is the role of your company in the industrial investment project?	• Owner/investor • Contractor • Design/engineering company • Other
What is your role in the company?	• Upper management • Middle/project management • Specialist • Buyer • Other
Describe your company and your role in the company (if you have anything to add to the first two questions)	Open answer
Describe the usual types of industrial investment projects that your company does	Open answer
What are the common challenges that your company faces during an industrial investment project?	Open answer
What section of the "project triangle" causes the most challenges for your company?	• Schedule • Scope • Budget • None of the above/no big differences between the above
How have challenges been solved in previous industrial investment projects?	Open answer

Does your company have a clear process for challenges during industrial investment projects?	• Yes • No
Describe the problem-solving process (if exists)	Open answer
In your opinion, what should the problem-solving process be like?	Open answer

Table 5. Questions of the first phase of the interview

The second phase is related to the different phases of an industrial investment projects. The different phases of the project were defined as the planning phase, predesign/concepting phase, design phase, procurement phase, construction phase, and maintenance phase. After the questions related to each phase, the interview ends with three overall questions related to the phases and industrial investment projects. The questions are presented in the following table.

Question	Answer options
Describe the common challenges that appear during this phase	Open answer
Estimate the amount of challenges during this phase and the effect of the challenges on the project	Scale from 1 to 5, where 1 is the smallest amount of challenges or the smallest effect and 5 is the biggest amount of challenges or the biggest effect
Which phase causes the most challenges for your company? Select one or more.	• Planning phase • Predesign/concepting phase • Design phase • Procurement phase • Construction phase • Maintenance phase
What percentage of industrial investment projects are completed within the agreed schedule, budget, and scope?	• 0-25% • 25-50% • 50-75% • 75-100%

What percentage of the completed projects require repair actions after the project is finalized?	• 0-25% • 25-50% • 50-75% • 75-100%

Table 6. Questions of the second phase of the interview

The interviews were done by contacting the interviewees first by a phone call and then via a Microsoft Teams interview. The length of the interviews varied from 20 minutes up to 40 minutes. The participants were also given a chance to fill out the interview via Google Forms themselves, if they did not have the time or did not want to do the interview via Microsoft Teams. Overall, a total of 29 people from different companies participated in the interviews. 17 of the interviewees worked for the investors/project owners, 6 for contractors, and 6 for design/engineering companies. 14 of the interviewees were a part of the upper management, 12 were a part of the middle/project management, two were specialists and one was a buyer. The interview data was collected via Google Forms and afterwards the data was combined to Microsoft Excel.

3.3 Data analysis

The data was analyzed in Excel tool by combining all the answers from the Google Forms survey. The open answer questions were analyzed in a way that the common themes that stood out were separated from the answers, making the overall analyzing easier.

The data analysis was done in two sections: first, by analyzing the answers from different types of actors in the project (owner/investor, contractor, design/engineering company) and then analyzing the answers from different positions within the companies (upper management, middle/project management, buyer, specialist). The split between the different companies and positions was done because for this research, the answers differ a lot based on the position or the company. For example, the upper management usually plays a bigger part in the planning phase, whereas the middle management or buyers play a bigger part during the procurement and construction phases. Also, some actors such as the contractors are often not involved in the planning process, so they could not answer questions related to that phase of the project.

4 EMPIRICAL RESULTS

4.1 Project owner's perspective

4.1.1 Upper management perspective

In the interview, five of the interviewees are a part of the upper management in a project owner or investor company. The projects that the interviewees most often work in varies from small changes to production lines to investing in entire production plants. Many of the interviewees answered that most of the projects are replacement projects, where part of the production line is replaced by something new.

The common challenges that the interviewees mentioned in investment projects are related to budget management, project planning and design and choosing the right projects on the right time. One interviewee answered that choosing the right project on the right time is very difficult, because there are a lot of new investment ideas and prioritizing these ideas is difficult. Other interviewee answered that actually realizing the idea is always a challenge. One of the main themes that the interviewees answered as a common challenge is the planning and design phases of the project. Some interviewees said that it is difficult to find design firms and contractors that have the required skills and knowledge for the projects. Also, according to most of the interviewees, the challenges during the early phases of the project may cause big challenges in the later phases of the project. If the design or planning is done poorly, the implementation and construction phase can be a big challenge.

During the planning phase, the interviewees answered that the biggest challenges are choosing the correct project idea on the right time and setting the scope for the project. The interviewees answered that if the wrong project is chosen at the wrong time, managing the budget and the schedule could be very difficult later in the project. Investment projects can take a long time to implement, so forecasting client needs and requirements and choosing projects based on them is hard, especially in today's world where the technologies are evolving rapidly.

During the predesign or concepting phase, the interviewees answered that the common challenges are related to planning the scope, budget, and schedule of the project. Many answers included underestimating the budget or the schedule of the project. Many also

answered that during this phase the project scope can change from the original plans, which then causes challenges to the other planning or predesign processes. One interviewee also answered that the other stakeholders are usually not involved in this project phase, which makes it more difficult to plan and design the project.

According to the interviewees, the biggest challenge in the design phase is related to the collaborating with the design company. Multiple interviewees said that the design company is brought to the project in the design phase, and that having enough documentation for the design company could be a challenge. Also, finding suitable design companies can be a challenge according to some interviewees. During the design phase, the scope of the project can also change according to the view of the design company. One interviewee mentioned that in their line of business, the design company is involved in the project from the beginning, which makes the design process easier.

In industrial investment projects, procurement phase follows the design phase. According to the interviewees, the common challenges in the procurement phase are finding enough resources to do the procurement properly and aligning the design and the procurement processes. One interviewee answered that the design process sometimes takes so long that the procurement must be started before the design finishes, which can be a challenge, since a part of the procurement must be done without the final design documents. Also, since industrial investment projects are unique and often very specific projects, the procurement can be a challenge because the resources needed can be new or rare.

During the implementation or construction phase, many interviewees answered that the challenges that have occurred in the previous phase can cause the biggest challenges during the construction phase. If the earlier phases are done properly, the construction phase is a routine process. Common challenges, according to the interviewees, are collaborating with all different stakeholders and making sure that everyone is focused on the project goal.

The last phase of the project is the maintenance phase. According to the interviewees, the challenges during the last phase are related to the project handover to the maintenance and involving the stakeholders responsible for the maintenance to the project early enough so the handover is easy. If the project data and handover is not done properly, the maintenance process can be difficult since the employees are not trained to use the new

equipment and machinery properly. Lack of training can cause big challenges, and even accidents, in the maintenance phase.

According to the upper management interviewees from the investor companies, the first three phases (planning phase, predesign and concepting phase, and design phase) are the most challenging phases of the project. Usually in industrial investment projects, the upper management is more involved in the early planning and design phases of the project, so the upper management is often aware about the challenges and effects of the challenges in the earlier phases, where they are mainly responsible of the decisions related to the project.

4.1.2 Middle/project management perspective

Ten of the 29 interviewees are a part of the middle/project management in an investor or project owner company. The projects that the interviewees most commonly work in varies from replacement investments to building projects. The common answers, when asked about the projects the interviewees worked in, were similar to the ones of the upper management.

According to the interviewees, the common challenges in industrial investment projects are related to different stakeholders. Many interviewees mentioned that good designers are hard to find and that having a lot of different stakeholders in the project can cause challenges in the project schedule, since if one stakeholder is late, the whole project schedule changes. Many also answered that the planning phase of the project is crucial, since if the project is not planned properly, the project is hard to execute on time. If the project is not executed on time, for example when replacing a machine in the production, it can cause stoppages in the production. Also, if the planning is not done properly and the documentation is incomplete, designing the project is very difficult.

Based on the answers, the biggest challenges in the planning phase are related to schedule and considering different factors when choosing between different project ideas. Many interviewees answered that the planning phase is often done on a tight schedule. In industrial investment projects, the decisions must be done quickly, but making decisions without enough knowledge can cause challenges. One interviewee mentioned that the decisions are sometimes done without knowing, for example, the price ranges of different equipment, which then leads to false assumptions regarding the project budget. Other

challenge is predicting the future and how long it takes for different projects to start making profit.

During the preplanning/concepting phase, the common challenges are managing the scope, budget, and schedule and stakeholder management. From the project management perspective, it is difficult to manage the resources for the project. One interviewee mentioned that managing the scope is difficult and that in the preplanning phase it is very important to consider all possible scenarios to minimize challenges during the later phases. Many interviewees also answered managing the stakeholders as a challenge. Transferring the planning documents to the design company is a challenging process, and the documents may sometimes be incomplete, which creates a challenge also for the designer. Also, following each stakeholder and their commitment to the project is a challenge during the early phases of the project.

From the project management or middle management perspective, in the design phase, the common challenges include finding a skilled design company, managing the stakeholders, and allocating enough resources to the design phase. Often in industrial investment projects, the documents provided to the design company are incomplete, and the schedule for the design is tight, which makes the design challenging, especially if the design company is not involved in the earlier phases of the project. Also, if the stakeholders are not involved earlier, committing all stakeholders to the common project goal could be a challenge according to some interviewees. If too little resources are allocated for the design phase, the design may be incomplete, which can lead to bigger challenges during the later phases.

The middle or project management saw similar issues in the procurement phase as the upper management, and most of the challenges were related to finding enough resources and time for the procurement phase. Many interviewees answered that often in industrial investment projects, too little resources and time are allocated for the procurement, which makes the procurement process very challenging. In industrial investment projects, negotiations with suppliers can take time, which can affect the project schedule or the budget. Also, incomplete design can cause challenges in the procurement phase if the procurement is done based on incomplete or badly done design.

In the construction phase, the common challenges according to the answers were related to solving the challenges in the previous phases and aligning the processes of different

stakeholders. Many interviewees answered that it can be a challenge to align the processes of different contractors and subcontractors and following each stakeholders' work requires additional resources from the project owner. Also, the challenges of the previous phases can cause big challenges on the construction, if for example the design is not fit for the actual site. If the design must be changed during the construction phase, the project can be delayed, and the budget can rise.

The last project phase is the maintenance phase. According to the interviewees, the common challenges in this phase are ramping up the production and providing resources for the new equipment and technology. Similar to the upper management, the middle and the project management employees answered that it is important to provide resources to the ramp up process and training to smoothen the process of moving from the construction phase to the maintenance phase.

According to the middle or project management, the most challenging project phases are the earlier phases (planning, predesign and concepting, and design phase). Also, some interviewees answered the procurement and construction phases as the most challenging phases if the challenges in the earlier phases are not solved before starting the procurement and construction.

4.1.3 Buyer or specialist perspective

Two of the 29 participants are either a buyer or a specialist in the investor or project owner company. One of the interviewees is working as a buyer and one as a specialist. Similar to the other interviewees that work for a project owner company, the buyer or specialist interviewees work mainly in building or replacement investment projects, where either something new is built or something is replaced by something new, such as production equipment or machinery.

From the buyer perspective, the common challenges in industrial investment project are related to the scheduling of the procurement and finding the specific parts or materials that are needed for the project. The interviewee also mentioned that the current world situation makes it very difficult to make procurement plans. From the specialist interviewee, the common challenges are related to choosing the right projects and making sure that the early phases are done properly. According to the interviewee, it is important that the project owner knows what they want to do in the industrial investment project

and that the project goal must be clear from the early phases. If the goal is not clear and the early phases of the project are not done properly, the later phases, such as the construction phase, can be very difficult.

In the planning phase, both interviewees had a similar view of the challenges. According to the interviewees, the common challenges are related to initial information and knowledge about the project. If the upper management does not have enough information about the subject, it is hard to estimate if the project is beneficial in the long run. Also, the upper management must know if it is possible to implement the project. For this, the interviewee suggested that the project stakeholders should be included in the planning phase to provide insight to the upper management.

In the predesign and concepting phase, the common challenges are related to estimating the project budget and schedule and understanding all the processes that are needed in the project implementation. According to the buyer, if the preplanning or concepting is not accurate enough, the design and procurement phases can be difficult. From the perspective of the specialist, in the concepting phase, it is important to have strong knowledge of the overall processes to design the needed machinery or equipment properly, and in industrial investment projects, the equipment or machinery are often very specific, which can cause challenges in the design.

According to the interviewees, the challenges in the design phase are related to the earlier project phases and collaborating with the design company. Both interviewees answered that if the planning and predesign phases are done properly, there are no big challenges in the design phase. However, because of too tight scheduling, the design process sometimes must be done too quickly, which can lead to incomplete design. Also, according to the specialist, it is very important to heavily collaborate with the design company to get the optimal design for the specific project.

In the procurement phase, the common challenges are related to the accuracy of the design and collaborating with the procurement unit, according to the interviewees. From the buyer perspective, incomplete design or too little resources can make the procurement phase very challenging. From the specialist perspective, collaborating with the procurement unit in big global projects is difficult, since the procurement unit sometimes wants to buy the cheapest possible materials. According to the interviewee, cheaper

materials often initially look like the best choice, but cause bigger challenges and additional costs in the long run.

During the construction phase, the challenges are related to planning the processes and collaborating with the stakeholders. Both interviewees answered that collaborating with different stakeholders is a key factor during the construction phase, and ineffective collaboration can lead to delays in the schedule or stoppages in the production. Also, the construction process must be aligned with other business processes, so that the possible stoppages are as short as possible. Planning and performing the construction phase requires resources, so also the resource allocation must be done correctly to avoid unnecessary challenges.

The last phase of the project is the maintenance phase. Similar to the upper management and the middle/project management, the interviewees answered that the challenges are related to training the staff to use the new equipment and machinery. According to the interviewees, it is important to train the employees properly to avoid unnecessary stoppages and risks.

According to the buyer and the specialist, the most challenging phases of the project are the earlier phases. The buyer answered that the planning phase is the most crucial phase of the project, and the challenges of the planning phase can cause challenges also in the later phases, if they are not solved early enough. The specialist answered that the predesign and concepting phase is the most challenging phase, since the predesign requires a lot of knowledge about the processes, and it must be accurate to prevent challenges in the later phases of the project.

4.2 Design company perspective

Five of the participants in the interview work in a design or an engineering company. Three of the participants are part of the upper management, two of the middle or project management, and one is a specialist. The common projects that these participants work in are investment projects in the chemical industry, various types of construction projects, and replacement projects, where the participants' main responsibilities include providing different types of design, for example design related to automation. The usual challenges that the interviewees recognize are that the early planning documents and information are

often not good enough, which makes the design phase challenging. Another common challenge is the project schedule, because managing the schedule in big unique projects is difficult, especially when the different project phases are dependent of each other. Big projects have a lot of stakeholders, and the communication between the stakeholders is slow, which can delay the schedule too. Also, some interviewees answered that it is difficult to find skilled employees for unique projects.

During the planning phase, the interviewees answered that they are often not included in the early stages of the planning process, which may cause challenges in the later phases of the project, because the needs and requirements of the designer are not considered if the designer is not included in the planning phase. Another challenge is that there can be misunderstandings in the plans, or the planning is done without having enough knowledge about the project or processes, which creates an unrealistic image of the project or too high expectations.

According to the interviewees, the common challenges in the predesign or conception phase are similar to the planning phase. The designer is not always included in the predesign or conception phase, which makes the predesign difficult. In an optimal situation, the designer is included in the project in a very early stage, so that the design risks and requirements are considered early. This makes the whole project smoother, since for example the technical details are considered early, which minimizes risks in the construction phase. If the designer is not included in the conception phase, the technical details may be wrong, and the construction phase can be very difficult. Also, the unrealistic plans that are done in the planning phase can cause challenges in the predesign, which can cause delays and increase costs in the project.

The design phase is often the phase where the designer is included in the project, which may cause challenges, according to the interviewees. The detailed planning is challenging if the planning documents are incomplete or not done well enough. If the earlier phases are done properly or the designer is included in the earlier phases, the design phase is usually not a challenge. One challenge that one of the interviewees mentioned is that nowadays the designers use cloud-based software to do the design, which could limit their knowledge on the project, since they do not have a concrete image of the building or machinery they are designing. This can lead to errors in the design.

In the procurement phase, the challenges of the earlier phases can cause challenges in the procurement if they are not solved early enough. According to the interviewees, selecting the suppliers properly is important, and if the predesign and design phases are not done well enough, choosing the correct supplier is difficult. Another challenge can be if the budget is not planned properly, which can lead to increases in the estimated costs when selecting the suppliers and buying materials.

From the perspective of the design companies, the construction phase is often routine work, and the challenges are related to daily activities. Common challenges that may come up in the construction phase are related to quality control, which must be done properly to avoid unnecessary risks and challenges. The quality control in a big investment project can sometimes be challenging, when the construction is done by many different contractors. Also, if the procurement is done too late, getting the material for the construction phase may be a challenge.

The last phase is the maintenance phase. According to the interviewees, there usually are no bigger challenges in the maintenance phase. Sometimes, there could be surprising maintenance activities, and finding employees to perform the maintenance activities can be a challenge. Overall, the challenges in the maintenance phase are routine work that do not need extra attention.

From the perspective of the design or engineering companies, the biggest challenges in industrial investment projects are the planning and predesign and conception phases of the project. According to the interviewees, the designer should be included in the earlier phases to avoid risks and challenges in the later phases.

4.3 Contractor perspective

Six of the interviewees answered that their companies are the contractors in industrial investment projects. All six are in the upper management. The common projects that the interviewees work in are various industrial projects in various industries. The interviewees, for example, answered that they work in all sizes of building projects, building and investment projects in the energy or chemical industries, and replacement projects in different industries.

The common challenges that the contractors face in industrial investment projects are lack of material due to the world situation, keeping the project schedules and lack of knowledge and expertise in design. Many of the contractors answered that in industrial investment projects, the quality of the planning and design is often not as good as it could be, which causes challenges and delays in the construction phase. Another common challenge that the contractors face is that industrial investment projects often have a lot of stakeholders, and if the communication between the stakeholders is not managed properly, it can cause misunderstanding and a lot of unnecessary documentation, which causes challenges especially to the contractor, who does the construction based on the needs and requirements of other stakeholders.

Only two of the six contractors answered that they are involved in the planning phase of the project. According to the two interviewees, the common challenges in the planning phase are that the contract offers come too late, which makes preparing for the construction difficult, and that the plans are often done on a too high level. When the planning is done on a too high level, there is no clear direction to the project, according to the interviewee. Also, only two of the contractors answered that they are involved in the predesign and conception phase, and both interviewees answered that there are no major challenges in the predesign if the planning phase is done properly.

In the design phase, the common challenges according to the interviewees are related to the design quality and involving different stakeholders to the design process. Multiple contractors answered that if the quality of the design is not as good as it could be, it can cause major challenges in the later phases of the project. Also, the design is often done on a too tight schedule, which then leads to unfinished documentation. The design is sometimes also too complicated and hard to understand, which makes the construction process more difficult. Another common challenge in the design phase is that the different stakeholders are not included in the design process. According to the contractors, there would be a lot less challenges in the later phases if the owner and the contractor were included in the design process and the requirements of the owner and contractors were considered.

In the procurement phase, the biggest challenge currently is the availability of material. Other common challenge according to the contractors is that in industrial investment projects, the needed materials are very specific, and the procurement phase requires

specific expertise. Specific materials are also hard to get, which means that there could be delays if the procurement phase must be done on a tight schedule.

According to the contractors, the challenges of the design and procurement phases create the biggest challenges in the construction phase. If the design is not done well enough or the materials are not available, there could be delays in the construction phase and the budget could increase. Also, sometimes the project staff is not experienced enough, which can cause challenges in the communication, especially in big industrial projects with a lot of stakeholders.

The last project phase is the maintenance phase. According to the contractors, the common challenges in the maintenance phase are related to the construction materials. Often the construction phase is done with the cheapest materials to keep the budget as low as possible, which can then backfire in the maintenance phase due to unnecessary breakdowns or repairs. Also, if the processes are not designed well enough, there can be reclamations from the owners or end users.

According to most of the contractors, the most challenging phase in industrial investment projects is the construction or implementation phase. The construction phase is the most challenging phase since the contractor is mainly responsible of the construction, and the contractor must deal with the challenges that are caused by the earlier phases, such as the planning and the design phase. According to the contractors, by involving more stakeholders to the earlier phases, there would be lot less challenges since the contractor usually has knowledge of what can be built within the plans.

4.4 Synthesis of the empirical results

In the table below are presented the key challenges of each project phase based on the interviews from the perspectives of the owner, the design companies, and the contractors. From the perspective of the owner, the different perspectives (upper management, middle/project management, and the buyer or specialist) were analyzed together and the most common or most meaningful challenges are presented in the table:

Project phase	Project owner	Design company	Contractor
Common	• Scheduling, budgeting, and estimating the project scope • Finding skilled project staff • Planning and selecting right investments on right time	• Too tight schedule for the design • Incomplete planning documents • Information flow between stakeholders	• Challenges in design quality • Plans are made with limited knowledge
Planning phase	• Selecting between different ideas • Having the needed knowledge of what can be done within the planned schedule and budget • Fitting the idea to company's processes	• Designer is often not included in planning • Often done by upper management of the owner, and the decisions are made with limited knowledge about processes	• Plans are too high level, no knowledge on what can be implemented • Contractors are often not included in this phase
Predesign/ conception	• Stakeholders are not properly involved • Changes in the project scope • Project is impossible to implement due to limitations in technology or processes • Challenges in documentation	• Plans change due to limited knowledge in planning phase • Unrealistic plans	• Similar challenges to planning phase, contractor often not included
Design	• Allocating resources properly • Different stakeholders have different goals • Finding skilled designers • Challenges of previous phases can cause challenges in design	• Finding resources and time for the design • Cloud-based design, limited knowledge about the construction site	• The needs and requirements of different stakeholders are not considered • Contractor is often not included in the design • Low quality of design

			• Design is done on a too tight schedule
Procurement	• Allocating enough resources to procurement • Challenges of previous phases affect the procurement phase • Too tight schedule • Unique and specific processes and materials cause challenges • Lack of documentation	• Selecting the right contractors • Schedule delays due to the contractor selection process • Lack of documentation from the contractors	• Specific materials are hard to get, which is often not considered early enough • Challenges of earlier phases cause too tight schedule for procurement • Current lack of material
Construction/ implementation	• Stakeholder and contractor management in big industrial projects • Project cannot be implemented within the agreed design plans • Lack of documentation in previous phases • Too tight schedule	• Material may not be available during construction, which causes delays • Changes in design • Collaboration between stakeholders • Construction quality	• The challenges of the design phase can heavily affect the construction • Schedule is too tight • Stakeholder management causes challenges, each stakeholder has their own interest • Plans and design could be hard to implement in reality
Maintenance	• Handover to end users, training • Transferring data and documentation between information systems • Allocating enough resources to handover and ramp-up	• The challenges in earlier phases can cause challenges in maintenance • Unforeseen breakdowns or failures	• Too cheap materials can cause unnecessary repair actions • If the requirements are not properly set, there can be reclamations from the owner

Table 7. Synthesis of the empirical results

5 DISCUSSION

Based on the interviews and the data gathered from the interviews, most of the interviewees are using the traditional project delivery methods when delivering industrial investment projects. According to the interviewees, most of the projects follow a similar pattern, where the owner first plans the project, then creates a contract with the design company and the contractors. Then, the company responsible for the design performs the design work for the project, and after the design is complete or nearly complete, the contractor or contractors do the implementation or construction based on the planning and design documentation. This pattern is used a lot in the traditional project delivery methods, such as the design-bid-build method (Touran et al. 2009). Although the contract models between the different traditional delivery methods differ, the common challenges are similar, and could also be identified from the interviews.

5.1.1 Planning phase

In the planning phase of an industrial investment project, the common challenges according to all three perspectives (the owner, design companies, contractors) were similar. From the owner's perspective, selecting between the potential investment ideas is a common challenge. Another challenge is having the needed knowledge in the planning phase. The same challenge is also common from the perspective of the design companies and the contractors. This challenge could be happening because in the traditional project delivery methods, such as the design-bid-build method, the knowledge is often siloed because the actors are separated from each other (Kortenko et al. 2021). In the traditional project delivery methods, the designer and the contractor are not involved in the planning, and the owner makes the decision based on their own knowledge. If the owner does not have enough knowledge of the project and what can realistically be implemented, it can lead to bigger challenges in the later phases of the project.

Collaborative delivery methods, such as the alliance or EPCA, include early integration of all project stakeholders (Hietajärvi et al. 2017; Kujala et al. 2020). The key benefits of the models include sharing knowledge from the very early stages of the project. This means that even in the early planning phase, the owner, the designers, and the contractors can share their insight on the project ideas and what can be done in the project within the agreed schedule and budget. The decisions are made in a collaborative way, which also

increases the transparency between the stakeholders. By using collaborative methods in the planning phase, the challenge of siloed knowledge could be decreased.

Early integration of the design companies and contractors may require additional resources, such as time and knowledge from the stakeholders that are usually not involved in the planning processes. However, early collaboration can be beneficial in many ways for the stakeholders since the rewarding system in model such as IPD are common (AIA National & AIA California Council 2007). Common rewarding system commits every party to a common goal. Using collaboration in the planning stage also decreases challenges in the later stages, where the design companies and contractors have more responsibilities of the possible challenges and delays, because using collaborative methods in the planning stage allows every stakeholder to set their needs and requirements in the earliest possible phase of the project.

5.1.2 Predesign/concepting phase

The challenges in the predesign phase are similar to the planning phase, according to the perspective of the project owners, designers, and contractors. For the owner, the most common challenges are changes in the project scope, challenges in properly documenting the project and the project being hard or impossible to implement due to limitations in technology or processes. For the designer, the most common challenges are unrealistic plans or plans that are difficult to implement. For the contractors, the challenges are similar to the planning phase.

In the traditional project delivery methods, the designer or the contractor are not often involved in the predesign phase. Like in the planning phase, the stakeholders not being involved could be one of the sources for the challenges. According to the interviews, the project owners see that the stakeholders not being involved creates a challenge in the predesign phase, since concepting the project requires more knowledge about the processes and technology related to the project and implementing the project. Similar to the planning phase, in the predesign phase, the decisions are made mainly by the upper and middle management of the project owner, and the perspective of the designer and contractors is not considered. Even though the middle management of the owner can share their insight on the processes and possible technologies, the knowledge can still be limited. For example, according to Bilbo et al. (2015), one of the main challenges in the

CMAR model is that the owner plans the whole project, which can cause challenges later, since making changes to the project is difficult.

Another challenge that the project owners see in the predesign phase is the lack of documentation. Lack of documentation can also cause siloed knowledge because the documentation is solely the responsibility of the employees in the owner company. This can lead to limited transparency, since the documentation may be limited, and there can be key information missing from the documents that are shared with the designer and contractors later in the project.

Using collaborative methods in the predesign phase could solve challenges in the predesign phase. Like in the planning phase, getting insight from the designer and contractors could help to solve the challenges related to having limited knowledge. When the collaborative methods are applied already in the planning phase, the project scope would be decided on collaboratively, and bigger changes in the predesign phase would not be needed as much. Also, insight from the designer and contractors could help solve the challenge related to technology and processes. When selecting the designers and contractors, owners can already gain insight on what specific skills and knowledge the possible actors have. When the stakeholders are decided early and their knowledge is applied to the project in the early phases, it is easier to know what can be implemented and which technologies can be used in the project.

Using collaborative methods can also improve documentation and communication in the project. For example, in the integrated project delivery method, the information systems and documentation systems are usually common between the stakeholders (AIA National & AIA California Council 2007). Having a common system or documentation flow allows every stakeholder to participate in creating the documentation and making sure that the information flows freely among the stakeholders. Common systems also ensure that everyone knows what is included in the documentation before moving to the next project phase. When every stakeholder knows what is happening in the project, setting milestones for each project phase is easier.

Selecting the needed stakeholders for the collaborative methods early in the project requires extra effort from the owner, since the owner must know what type of designers and contractors they need for the project in a very early stage. Selecting the correct candidates in unique and specific industrial investment projects requires resources, and it

could be hard to estimate the skills and knowledge of the possible stakeholders without knowing the project plans. However, methods such as the EPCA offer a framework for selecting the candidates (Kujala et al. 2020). Also, as Lahdenperä (2019) mentions in his article, successful collaborative projects increase the reputation of all stakeholders, making it easier to collaborate with them in future projects too.

5.1.3 Design phase

In the design phase, the challenges are similar to each other from the perspectives of the different stakeholders in industrial investment projects. For the project owner, the biggest challenges are allocating the resources for the design phase, finding skilled designers and the situations when the different stakeholders pursue their own goals rather than committing to the common project goal. From the designers´ perspective, finding the resources is considered a big challenge as well. Also, some designers mention the cloud-based design, where the designers design the project in a virtual environment a challenge. For the contractors, the biggest challenges are the quality of the design, the tight schedule of the design phase and not including the contractors in the design process.

In traditional project delivery methods such as the design-bid-build method, the design is always done before the construction (Touran et al. 2009. In traditional delivery methods, the contractors and subcontractors are not often included in the design process. Not including the contractors limits the design process in a way that the contractors cannot give their insight on the design, and if the design is possible to implement or not. In worst case, the separation between the actors can even cause conflicts. Also, in traditional project delivery methods the decisions regarding the budget and schedule are often done by the owner before the other actors are involved in the project. This can lead to tight schedules in the design phase if the scheduling has not been done properly. Often, the project designers and owners have limited knowledge of the needed materials and the construction environment, which can lead to poor decisions in the design.

Using collaborative methods in the design process could improve the quality of the design. Involving the contractor in the design process allows the contractor to share their insight on what is realistically possible to implement or construct in the construction environment. Even if the design is being done virtually, the insight of the constructor can help to solve the design challenges. For example, one of the key benefits of using the alliance model is that each party has a better understanding of the project (Lahdenperä

2009). In unique industrial investment projects, having a better understanding about the different processes and the different stakeholders could improve the performance of the whole project team. Also, like in the other phases, using collaborative methods can help to commit everyone to the common goal, which can help solve the challenge where everyone is pursuing their own goals, which is a common challenge in traditional delivery methods, according to Kortenko et al. (2021).

Involving the contractors in the design phase could require some additional resources from the actors. The design could, at first, be slower since the designers would have to listen to the insight of the contractors before proceeding with the design process. Also, the contractors would need to learn about the design process so they could provide their insight on the process. However, using the collaborative methods in the design phase could help to solve the bigger long-term challenges, such as the challenges in the design quality. The collaborative methods, such as the EPCA model, provide frameworks which can help the stakeholders to adapt to the collaborative methods (Kujala et al. 2020). Also, as design phase is one of the most crucial phases for the industrial investment project, limiting the challenges is important, and having less challenges could also decrease the challenges in the later phases, such as the procurement and construction.

5.1.4 Procurement phase

In the procurement phase of the industrial investment projects, the common challenges are related to resources, unique and specific materials, lack of resources, and lack of documentation. The designers also mention that selecting the contractor can be a challenge and that the selection process may cause delays in the whole project. From the perspective of the contractor, getting unique materials is a challenge, especially in today´s global material shortage situation.

In traditional project delivery models, the contractors are often selected during the procurement phase of the project. The contractors are selected based on different criteria, such as price and availability (ACCM 2017). The contractors then can send the list of needed materials to the project owner, and the procurement division can proceed with the procurement process. As the designers mention in the interviews, the contractor selection process can be a long process, especially in unique projects that require specific expertise from the contractors. The selection process also requires resources from the owner, and if the process is done with too little resources, the selected contractor may not be the best

available option. Another challenge is getting the unique materials for the project. If the availability of the materials is not considered early enough, getting the materials on time could be a major challenge, and the lack of materials could cause delays in the project. Also, if the procurement is done on a too tight schedule, the materials could be expensive, which can increase the project budget. The third main challenge in the procurement phase is the lack of documentation. The designers often do not get enough documentation from the contractors, and for the owner, the lack of documentation is a challenge overall. This could be because with separate actors, the knowledge and documentation are siloed, and there is no transparency in the project.

Like in the other phases, collaborative methods could be used to solve the challenges in the procurement phase. Selecting the contractors in the early phases of the project could prevent the challenges in the procurement phase, since having the contractors available throughout the whole project can prevent delays in the procurement phase. In models such as the integrated project delivery, the contractors are involved in the project from the beginning, which allows them to share their insight of the needed materials earlier (AIA National & AIA California Council 2007). This way, it is possible to buy these materials early, which can prevent delays, since the material is more likely to be available when needed. Also, the materials are often cheaper when they are bought earlier. Using models like the integrated project delivery or project partnering also increases the transparency in the project, since the information systems or information flow is common between the actors (AIA National & AIA California Council 2007; Lahdenperä 2012). This way, the documentation is constantly available for all project stakeholders, and there are no knowledge silos or gaps in the documentation flow.

Finding the right contractors early in the project for the specific processes could be a challenge when using collaborative methods. The owner may not know, what specific expertise is needed later in the project. However, methods such as the alliance method have proven to increase the reputation of all stakeholders, including the contractors. This way, it could be easier to find the correct contractors in upcoming projects, since the owner knows which contractor has a good reputation. Also, successfully collaborating in one project can lead to longer term collaboration between the owner and the contractor, which makes the contractor selection process even easier.

5.1.5 Construction/implementation phase

From the perspective of the project owners, the big challenges in the construction or implementation phase were stakeholder management in large industrial investment projects, lack of documentation in the previous phases, tight schedule and implementing the project within the agreed plans and design. The designers also mention the collaboration between stakeholders as a challenge. Other common challenges from the perspective of the designer in the construction or implementation phase are construction quality, and material availability. From the perspective of the contractors, the main challenges are also tight schedule, stakeholder management and unrealistic design plans. Another challenge from the contractors´ perspective are the challenges of the design phase, which can, in worst case scenario, heavily affect the construction.

In traditional project delivery methods, the construction or implementation phase is usually performed by the contractor, who can then use subcontractors if needed. In the design-build, the company who is responsible for the design is also responsible for the construction (Bausman & Carpenter 2016). The owner can hire a construction manager to supervise the construction, but often the owner has very little to do with the construction phase. In traditional project delivery methods, risks are often not shared, so the company that is responsible for the construction is the one who is also responsible for all the risks related to the construction. If the contractor, or in the design-build method, the company responsible for design and construction, runs out of money, the risk for the owner is that the project gets heavily delayed or unfinished (Fernandez-Solis & Cugh 2018). Collaborative methods, such as the integrated project delivery and project partnering, include shared risk and reward sharing. Sharing the rewards and risks commits everyone to the common goal and decreases the risk that the contractors or the owners pursue their own effort without caring about the actual outcome of the project or the other stakeholders (AIA National & AIA California Council 2007).

Based on the interviews, the stakeholder management is a very common challenge in the construction phase. In large industrial investment projects, the construction site often has many different subcontractors, who are responsible for their own areas in the site. Managing the different actors in the construction site requires effort from the contractor or the project owner. One of the key benefits of collaborative methods, such as the project partnering, is that the roles in the project are defined clearly and the whole project must be as transparent as possible (Lahdenperä 2012). Defining the roles clearly in the

construction site makes managing the process easier, and improving transparency makes it easier for all stakeholders to continuously follow the project. Like in the other phases, transparency also increases the level of documentation between the different stakeholders.

One of the challenges from the perspective of the designers is the construction quality, whereas one of the challenges from the perspective of the contractors is the design quality. Having separate actors could be one of the reasons for both challenges. In traditional project delivery methods, the contractors do not have visibility to the design process, and the designers may not have enough knowledge about the construction. Using collaboration in both design and construction, the contractor can give their insight on the design, and the designer can give their insight on the construction process and what is needed in the construction. Collaboration reduces the knowledge gap between the stakeholders, which can help to prevent challenges in all project phases, especially in the design and construction phases. Collaboration also helps to anticipate the possible risks in the construction and procurement phases, such as the possible lack of material.

5.1.6 Maintenance phase

The maintenance phase is the last phase of the project. During the maintenance phase, the project is moved from the construction or implementation to ramp up and maintenance. From the perspective of the owner, the main challenges of this phase are finding resources for training the staff to use the new equipment and transferring data between the people and information systems. From the designers´ perspective, the main challenges are unforeseen breakdowns and the challenges from the earlier phases. From the perspective of the contractors, the biggest challenges are caused by too cheap materials that can cause unexpected breakdowns and reclamations if the project requirements are not properly set.

The project owner is mostly responsible for the maintenance phase of the project. Training the staff to use the new equipment or the machinery is done by the owner. However, collaborating with the contractor and designer could be beneficial for the training process. The contractor, for example, can give their insight on how the new machinery should be properly used, and the designers can provide important design documents and plans that the staff can use to learn more about the machinery. This way, using collaboration could smoothen the process of transferring the new equipment or

machinery to the maintenance phase. Also, by using common information tools, transferring the data and documentation to the end users is easier.

The contractors mention cheap materials as one of the main challenges in the maintenance phase. During the interviews, some contractors mentioned that sometimes the owners want to buy the cheapest possible material so that the project would be as cheap as possible. This can lead to bigger costs in the long run. By collaborating with the contractors in the procurement phase, the contractor can provide the owner insight on what materials are the most sustainable. Using the best possible materials could prevent unexpected breakdowns and unnecessary repair actions. Unnecessary repair actions can be a big risk to the owner, as they can cause stoppages in the production. Another challenge that the contractors mention is setting the requirements properly. If the requirements are not set properly, there can be reclamations from the end users. Using collaboration in setting the requirements could help to solve this challenge. Using workshops in the early phases of the project and having common decision making, like in the project partnering method, every stakeholder is aware of the requirements from the beginning of the project, which can help to prevent misunderstandings (Lahdenperä 2017).

5.1.7 Synthesis of using the collaborative methods to solve the challenges in industrial investment projects

Using collaborative methods in industrial investment projects requires resources and commitment from every stakeholder. For example, the owner must make decisions about who they need and want in the project team in the early phases of the project. In traditional project delivery methods, the project owner can make the separate contracts based on the planning phase. In collaborative methods, such as the alliance method, the alliance team is formed in the first phase of the project, and in the formation phase, each stakeholder must build the knowledge needed to successfully perform the project (Hietajärvi et al. 2017). In unique industrial investment projects, building the required knowledge could be challenging, which is why the collaboration with the stakeholders must be as transparent as possible from the very early stages to reduce the possible knowledge gaps between the different stakeholders.

Industrial investment projects consist of subsequent phases, and the project moves from one phase to another based on the requirements of each phase. Based on the interviews,

the owners and the designers think that the early phases of the project are the most challenging phases, whereas the contractors think that the construction or implementation phase of the project is the most challenging. In traditional project delivery methods, that most of the interviewees use, the contractors are responsible for the construction phase, which could explain the opinion that the construction phase is the most difficult phase. However, in the interviews, many of the contractors mentioned that the construction phase is the most difficult phase because the challenges in the earlier phases, such as the design phase, heavily affect the construction phase, and reducing the challenges in the early phases would make the construction phase smoother and easier overall.

Based on the interviews and the analysis, collaborative methods could be used to solve challenges in industrial investment projects. Based on the interviews, the planning phase, the predesign/concepting phase, and the design phase are crucial phases that can determine if the project is successful or not. Using collaborative methods in the early phases could be a key to solving the biggest and the most common challenges. Many of the challenges were a result of siloed knowledge, miscommunication, lack of transparency or stakeholders not being involved in the phases. Using collaborative methods is a proven way of reducing these challenges, as collaborative methods, for example, increase transparency. Also, in the collaborative methods, all stakeholders are involved in the project from the beginning, which means that the knowledge is less likely to be siloed and every stakeholder can provide their insight on the decisions.

Collaborative project delivery methods, such as the integrated project delivery, alliance, and project partnering, require the commitment from every stakeholder, and collaborative methods should only be used if every stakeholder is fully committed to the collaboration. There could be challenges in using collaborative methods, such as committing to the common information systems or continuously sharing knowledge with the other stakeholders. Also, as Pauna et al. (2021) write in their article, industrial investment projects require flexibility since the project schedules can be hard to predict, which could cause challenges. Other challenges mentioned by Pauna et al. (2021) include adapting to the collaborative methods. Sometimes, the actors are not willing to adapt to the collaborative practices since they are not familiar with them (Pauna et al. 2021). However, the collaborative methods offer a lot of frameworks and steps that can help adapt to the collaboration. For example, the EPCA and the project partnering methods offers frameworks for collaboration, that can be tailored to every project (Kujala et al. 2020).

The models include tools such as decision trees and workshops, that can be used to increase the collaboration between the stakeholders. Using these types of tools could smoothen the transition from traditional project delivery methods to more collaborative methods.

As Pauna (2022) writes in his article, models such as EPCA are developed to combine collaborative elements to traditional project delivery methods to increase performance. Instead of being completely new methods to deliver projects, collaborative methods can be used to combine the best elements of traditional delivery methods and the elements from collaboration that are beneficial for the project. As mentioned by Pauna (2022), unique industrial investment projects could be difficult to implement by choosing a ready model and sticking with that model, which is why the collaborative methods, such as the EPCA method, should be tailored to each project. Instead of being a complete project implementation model, the collaboration should be used as a tool to support delivering the project collaboratively (Pauna 2022). This way the effect of the collaborative methods to industrial investment projects can be maximized.

In the table below are summarized the most common challenges of each project phase and the ways to use collaborative methods to solve the challenges:

Project Phase	**Common challenges**	**Ways to use collaboration to solve the challenges**
Planning phase	• Too little knowledge about the investment ideas • Knowledge is siloed	• Including all key stakeholders enables more insights and shared knowledge
Predesign/concepting phase	• Project scope changes • Unrealistic plans	• All key stakeholders should be involved in providing their contribution on what can be implemented within the agreed plans.
Design phase	• Limited resources • Quality of the design • Stakeholders have different goals and needs	• Collaboration can increase quality and mutual understanding because then there is more knowledge about the processes

		• By agreeing goals together in earlier phases, stakeholders commit to them, making it easier, for example, to allocate resources
Procurement phase	• Unique materials are hard to get • Selecting the contractors can be a long process	• By selecting the contractor early, the procurement phase is easier, and the contractor can provide insight on the needed materials earlier
Construction/implementation phase	• Stakeholder management and collaboration between stakeholders • Quality of design and construction • Managing the schedule	• Collaborative methods emphasize the common goal setting, joint decision-making and best-for-the project mindset, which helps to align the interests of key stakeholders and manage other stakeholders • Designers and contractors can collaborate to improve the quality and to manage the schedule better
Maintenance phase	• Unforeseen breakdowns due to challenges of previous phases or too cheap materials • Training the end users	• By involving the contractors earlier, they can help choose the best materials • Every stakeholder can provide their insight and knowledge to the training process

Table 8. Summary of the challenges and the ways of using collaborative methods to solve the challenges

6 CONCLUSIONS

6.1 Key results

The aim of this research was to research how collaborative methods could be used to solve common challenges in industrial investment projects. The research was based on existing theory about industrial investment projects and project delivery methods, along with interviews to gain practical data about the common challenges in industrial investment projects. The practical contribution of this study was to provide suggestions on how to implement the presented collaborative methods to industrial investment projects and how to approach using the collaborative methods. The research questions for this research were:

RQ1: What are the key characteristics of industrial investment projects and the different ways to deliver the projects?

RQ2: What are collaborative methods and how are they used in projects?

RQ3: How collaborative methods can be used to solve typical challenges in industrial investment projects?

The first two research questions were answered in the literature review of this study. Project is a set of tasks done to produce a goal or a product. Industrial investment projects are often unique projects that can, for example, produce new machinery to replace old ones or new manufacturing sites. Industrial investment projects can be divided into different phases, such as the investment preparation phase, planning phase, project execution phase, and operations phase. Managing industrial investment projects requires knowledge about both project management and the technical side of the project. There are several ways to deliver industrial investment projects. The traditional delivery models include the design-bid-build model, design-build model, the construction manager at risk -model, and the EPC and EPCM models. The traditional project delivery models share similarities, but also differ from each other, usually on a contractual level.

Collaborative methods mean interorganizational activities that are used in projects, and they include sharing resources such as knowledge to reach a common project goal. The

collaborative methods include the alliance model, the integrated project delivery model, project partnering, and the EPCA model. The collaborative methods offer various tools and ideas to deliver projects in more collaborative and effective ways. The methods are unique and differ from each other, but they all share some common principles. These principles include, for example, early integration of all stakeholders and common decision-making.

Collaborative methods can be used to solve challenges in industrial investment projects in many ways. Based on the research, the most challenging phases of the projects are the early phases of the project, which includes the planning phase, the predesign/concepting phase, and the design phase. These phases can be challenging because the different actors, such as the designers and contractors, are not often involved in these phases. The collaborative methods can be used to involve every actor to the project from the beginning. This could decrease the challenges, as every stakeholder could provide their insight on the decisions. Also, involving everyone in the planning or predesign could make it easier to set the requirements for the project. There are also many other ways to solve the common challenges in industrial investment projects, that are presented in the discussion part of this research but concentrating on the early phases is a key to solving many of the challenges in the projects. Of course, there are challenges related to implementing the collaborative practices, such as adapting to the ways of working and committing everyone to the common goals, but the collaborative methods, such as the EPCA model, provides frameworks and steps to adapt the collaboration, which can make the adaptation process smoother.

6.2 Managerial implications

The goal of this research was to provide the project stakeholders solutions to the common problems in industrial investment projects. As all the interviewees answered that they are using traditional delivery models in the projects, this research can provide them ways to implement collaborative methods to their projects.

The finding of this study should guide the project owners to increase the collaboration with the other stakeholders, such as the early involvement. The different collaborative models can be used for different purposes. For example, the EPCA model or project partnering can be seen as easier ways to implement collaborative elements to the projects,

if the project organization has not used collaborative methods before. The owner company should use the frameworks provided by the collaborative models to increase the collaboration step-by-step. For example, using workshops to implement the collaboration could be used to smoothen the adaptation process. The owner should also use this research to implement the collaborative methods in different phases of the project. The owner can use this study to find the common challenges in the project and adapt collaborative elements to solve the challenges.

Another matter that the project stakeholders should consider when using the collaborative methods are the challenges of implementing the collaborative methods. Especially if the project staff is not experienced in using the methods, the collaboration should be implemented slowly. Adapting to models such as the alliance model could be very challenging, because it requires to fully adapting to the collaboration from the beginning of the project. The collaborative methods should instead be used as tools to increase the collaborative activities and elements that boost the performance of the project. Using the collaborative methods may require some additional resources from each stakeholder, but when properly executed, the collaborative methods are a proven way to increase performance.

6.3 Limitations of the research

The conducted study provides clear results and improvement suggestions for the project companies to implement collaborative methods to improve the project performance. However, there are limitations in the results, which should be considered. As usual in a master's thesis, the research was only done by one person, which may cause limitations, even though the researcher aimed to be as thorough as possible when conducting the literature. Also, as the research was qualitative and was based on semi-structured interviews, interpreting the results and the data was a responsibility of the researcher, which should be acknowledged. The validity, reliability and generalizability of this research can be evaluated based on a framework presented by Noble and Smith (2015).

According to Noble and Smith (2015), validity means the precision of the findings when compared to the data. The researcher has carefully gone through the interviews to be as precise as possible with the findings. However, a broader view could have been gotten if

there were more interviewees from the different roles of the contractor and designer companies.

Reliability means the consistency of the analytical procedures used (Noble & Smith 2015). According to Noble and Smith (2015), it includes accounting for any biases that may have influenced the findings. In this research, the biases of the interviewees may cause some decrease in the reliability. However, the data of the interviews can be seen as consistent and reliable since the interviewees were carefully selected together with the case company.

According to Noble and Smith (2015), generalizability means the transferability of the findings to other contexts. In case of this research, the findings can be transferred to any project settings, as the research was not limited to any specific industry. As such, the findings present a generalizable basis for using collaborative methods to solve challenges in industrial investment projects.

6.4 Future research

The topic of this research could be researched further by implementing the ideas in an actual project environment. Implementing collaborative methods in a company that has previously been using traditional project delivery methods could be a way to research the possibilities and limitations of the collaborative methods in practice.

One topic for future research could be researching, if the challenges that were mentioned in the interviews are caused by lack of collaboration, or just lack of expertise of knowledge from the project staff and stakeholders. Since the interviews are based on the view of each individual, it could be beneficial to research the projects further as someone who is not a part of the project staff. This way, a more objective view of the challenges in different project phases could be gained.

Also, one topic for future research could be to research the different collaborative methods in action. By researching the different methods, a broader view the challenges and possibilities of the methods could be gained. For example, researching how quickly the project stakeholders can adapt to the different collaborative methods could be a good

way to see, which collaborative method should be applied to which type of industrial investment project.

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