Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Economics and Management
Dept. of Industrial Economics and Technology Management

Torstein Hellebust
Irene Klary Annelies Buijing

Enhancing Collaborative Project Delivery in the Norwegian infrastructure industry

Enabling a holistic perspective through Early Contractor Involvement, Collaboration and Technology

Master's thesis in Project Management
Supervisor: Ola Edvin Vie
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Abstract

The multi-billion infrastructure industry is often criticized due to low efficiency and high failure rates. To remedy this situation a set of new collaborative project delivery systems have appeared. In this thesis we aim to examine the challenges related to such systems. This is done through answering the following research question:

> *How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?*

To answer this question, we performed a literature study to identify the challenges related to collaborative project delivery. However, we found that the theory was lacking a proper definition for this concept as authors usually address specific systems like Integrated Project Delivery, Alliancing, etc. Thus, in order to discuss CPDS as a concept we saw the need for a definition that covered all of these systems. Therefore, we formulated the following definition based on a comparison of these systems: *A collaborative project delivery system is a system that aims to improve the efficiency of projects through early contractor involvement, collaboration between participants and utilizing technology to enhance communication and collaboration. They may utilize specialized contracts, but can also exist within existing standards of local procurement laws.* Subsequently, we found that the elements, Early Contractor Involvement, Collaboration and Technology (ECT) are the most important factors. So we created the ECT framework, which addresses the different challenges related to collaborative project delivery through a set of theoretical propositions.

Next, we performed a qualitative case study where we examined two Norwegian Public Infrastructure Projects. We conducted semi-structured interviews with different participants with a total of five informants from each project, to collect data. We coded the data with the Gioia method where after we analyzed it. We used the data to examine our propositions and to evaluate and complement our ECT framework. There are three major findings from our research. The first is that the existing theory emphasizes too much on the owner's role and neglects the contractor's role. Our second finding is that collaboration can be established by holistic use of various measures to enhance collaboration, which deviates from the existing theory which focuses on individual implementation. Finally, the theory has an extensive focus on training with technology, whereas our study shows that establishment of a framework on how to use the technology collaborative is equally important. The conclusion of our study is that to overcome the challenges of a CPDS, a holistic implementation of the ECT framework is necessary. To strengthen the ECT framework, we suggest that similar research is performed in other context and that the use of a facilitator is examined further.

Samandrag

Infrastruktur industrien omsett årleg for fleirfaldige milliardar. På tross av dette vert den ofte kritisert for lav effektivitet og høge feilrater. Som eit svar på dette har det dei siste åra oppstått ei rekke nye prosjektgjennomføringssystem. I denne masteroppgåva undersøker vi utfordringane knytt til desse systema. Forskingsspørsmålet for oppgåva er:

> *Korleis kan norske infrastruktur prosjekt løyse utfordingane knytt til prosjektgjennomføring i samspel (Collaborative Project Delivery).*

For å identifisere utfordringane knytt til prosjektgjennomføring i samspel, utførte vi ei litteraturstudie. Under arbeidet med denne oppdaga vi at litteraturen mangla ei god definisjon for dette konseptet, då fleirtalet av forfattarar adressearar enkelt system, som t.d. IPD, Alliancing, etc. For å mogleggjere diskusjonar på tvers av systema laga vi ein definisjon som omfattar fleire typar prosjektgjennomføring i samspel. Definisjonen er basert på ei samanlikning av dei ulike systema og lyder slik: prosjektgjennomføring i samspel er system som søkjer å effektivisere prosjekt gjennom tidleg involvering av entreprenør, samspel mellom prosjektdeltakarane og bruk av teknologi for å forbetre kommunikasjon og samarbeid. Systema kan nyttegjere særeigne kontraktar, men dei kan og være tilpassa lokale innkjøpslover og kontraktstandarar. Litteraturstudiet peika og på at tidleg involvering av entreprenør, samspel og teknologi var avgjerande for å lukkast med samspelsprosjekt. Basert på dette utvikla vi ECT modellen, som beskriv dei mest framtredande utfordringane ved prosjektgjennomføring i samspel, gjennom eit sett med teoretiske proposisjonar.

Etter litteraturstudiet gjennomførte vi en kvalitativ casstudie der vi såg nærare på to infrastrukturprosjekt i Noreg. Datainhentinga bestod av semistrukturerte intervju med fem deltakarar frå kvart prosjekt. Dataa vart koda ved hjelp av Gioia metoen. Vidare vart dei brukte til analysere dei teoretiske proposisjonane og til å evaluere og komplimentere ECT modellen. Studien vår framhevar har tre hovudfunn. Det første er at litteraturen fokuserer for mykje på byggherrerolla, og for lite på entreprenørrolla. Vidare fann vi at litteraturen langt på veg seier at trening er den viktigaste suksessfaktoren mtp. teknologibruk. Funna våre tilseier at det er minst like viktig at det etablerast eit rammeverk for korleis ein skal bruke teknologien til å framme samspel. Til sist fann vi at teorien foreslår ei rekke individuelle tiltak for å for å framme samspel. Våre funn tilseier at tiltaka gjev best effekt dersom dei settast i samanheng og innførast som ei pakke. Konklusjonen på studien er at ein heilheitleg innføring av ECT modellen er nødvendig for å løyse utfordringane knytt til prosjektgjennomføring i samspel. For styrke å ECT modellen anbefaler vi å gjennomføre ei liknande studie i ein annan kontekst og at ein ser nærare på bruken av fasislitatorar.

Preface

This master thesis is written as part of our Master degree in Project Management at the Norwegian University of Science and Technology (NTNU) at the Department of Industrial Economics and Technology Management during the spring of 2021. The thesis builds on our project thesis, Buijing and Hellebust (2020), where we conducted a literature review in order to build a theoretical foundation for the master thesis.

The master thesis has been under the supervision of Ola Edvin Vie. We are thankful for his guidance and assistance during the whole project. He has given us valuable insights and support. The thesis would not have been the same without his assistance.

We would also like to express a special thanks to our case company and our contact Martin Amdal. Without them we would not have been able to conduct the research needed to fulfill this master thesis.

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Abbreviations

AEC Architecture, Engineering and Construction. 1, 6, 7, 30, 31, 81, 94

BIM Building Information Modeling. 9, 26, 27, 48, 50, 58

BVP Best Value Procurement. 48, 94

CMR Construction manager at risk. 7, 9, 12

CPDS Collaborative Project Delivery System. vi, 1, 2, 4, 6, 9–14, 17, 20–23, 25, 26, 28, 30, 32, 33, 49, 62, 65, 68, 70, 72, 74, 79, 80, 82–84, 86–89, 92–96

DB Design-Build. 7, 9, 12, 48, 51, 65

DBB Design-Bid-Build. 7, 67

ECI Early Contractor Involvement. vii, 1, 11, 14, 15, 17–20, 32, 51, 65, 66, 68, 77, 87, 88, 92, 95

IPD Integrated Project Delivery. 9, 10, 32, 33, 45

PDS project delivery system. ix, 4, 6–9, 11, 13, 14, 21, 48, 93, 96

PP Project Partnering. 10

TPDS Traditional project delivery system. 1, 6–9, 13, 17, 21, 23, 96

1 Introduction

In 2018, the Norwegian Architecture, Engineering and Construction (AEC) industry had a combined turnover of over 600 Billion NoK and employed over 255 000 people (SSB, 2018), making it one of the largest industries in Norway. Infrastructure projects account for a large part of this turnover and the Norwegian government has allocated 1064 Billion NoK to infrastructure projects in the period 2018-2028 (St.prp.nr.33, 2017). Despite the enormous amount of resources used on infrastructure, the industry is frequently criticized for low performance and poor project execution. Flyvbjerg, Skamris Holm and Buhl (2003) find that nine out of ten infrastructure projects experience cost escalation. Furthermore, they find that the average cost escalation is 28% and that this has been a continuous problem for over 70 years. Similarly, Samset (2014) argue that there are major problems related to cost and time overruns in a substantial amount of public construction projects. Hanna (2016) also addresses this problem and states: "the construction industry is fraught with waste and inefficiencies resulting in projects often failing to meet owners' expectations (p.1)."

In addition, there seems to be agreement among authors that the construction industry is struggling to cope with increasing complexity. Fischer, Ashcraft, Reed, and Khanzode (2017) argue that the AEC industry has become vastly more complex in the past twenty years and that this has resulted in an increased need for coordination. Similarly, Senescu, Aranda-Mena and Haymaker (2013) state that "The architecture, engineering, and construction (AEC) industry delivers increasingly complex projects but struggles to leverage information technology to facilitate communication on these projects (p.183)." Furthermore, Whang, Park and Kim (2019) claim that there is a need for increased collaboration in order to manage the huge amount of information and activities in construction projects. Based on these statements, we question whether the current project management practises in the AEC industry are satisfactory?

To remedy this situation, a set of new Collaborative Project Delivery System (CPDS) has appeared (Engebø et al., 2019). This set includes systems such as IPD, IPD-ish, Alliancing and Contractor managed DB (Hanna, 2016; Engebø et al., 2020c). There are many similarities between the systems and it seems that the most prominent characteristics are the use of Early Contractor Involvement (ECI), collaboration and the utilization of new technology (AIA California Counsil, 2007; Fish and Keen, 2012; Engebø et al., 2020c). However, existing theory is lacking a good definition that covers all of the mentioned systems, as authors usually address a specific system. Hanna (2016) state that there is statistical significant evidence that these systems outperform the Traditional project delivery system (TPDS). However, the utilization of CPDS also

introduces a new set of challenges (Roy, Malsane and Samanta, 2018) that should be addressed to achieve the intended benefits.

The use of CPDS is relatively new in the Norwegian infrastructure industry. Hence, there has not been performed many studies on CPDS within this context. This thesis aims to provide the scholars and practitioners within the Norwegian infrastructure industry with insights related to the challenge of CPDS and how to overcome them. We believe that these insights can contribute to create more efficient infrastructure projects. Due to the huge amount of resources that is used on infrastructure projects, even marginal contributions can lead to large cost savings. The research question for this thesis is:

> *How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?*

To specify the research question and the scope of the thesis even more, we are introducing a set of sub research questions (see. section 2.4, *Overview of product delivery systems*). To answer these questions, we are performing a case study where we examine two collaborative infrastructure projects in Norway. In the study, we are interviewing informants from the three main participants in the projects, the owner, the designers, and the contractors, to identify which challenges they have encountered and how they have handled them. Throughout this thesis we adapt a project management perspective and aim towards a holistic perspective to CPDS. Thus, we are not able to go very deep into the details of the different issues, as we asses that this would dilute the overall perspective that we are trying to create. In the next sub chapter, we are describing how we have structured the thesis and the content of the different chapters.

1.1 Thesis structure

- **Chapter 1 Introduction** Introduces the topic and purpose of this research project.
- **Chapter 2 Project Delivery Systems** Defines important concepts and presents the context of the study and our sub research questions.
- **Chapter 3 Challenges with Collaborative Project Delivery** Examines existing literature related to the challenges of CPDS to establish a set of theoretical propositions.
- **Chapter 4 Methodology** Describes in detail how this research project is designed and conducted.
- **Chapter 5 Empirical Findings** Presents the empirical data that is collected during this research project.

- **Chapter 6 Analysis** Evaluates the theoretical propositions from Chapter 3 based on the empirical data.
- **Chapter 7 Discussion** Discusses the theoretical implications of the analysis.
- **Chapter 8 Conclusion** Presents our answer to the research question, limitations and recommendations for further research.

2 Project Delivery Systems

Our research question, *"How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?"*, narrows down the scope of our study as well as it places it in a context, Norwegian infrastructure projects. Therefore, we are describing infrastructure projects in this chapter. The existing theory studies and explains various project delivery systems, traditional and integrated, but lacks an overall definition on CPDS. Therefore, we are briefly describing and comparing the different project delivery system (PDS)s described in our reviewed literature. Based on this comparison we are formulating a definition of CPDS. We are concluding by creating sub research questions that will form a base for our ECT framework, which we will complement during this thesis.

2.1 Infrastructure Project and Project Delivery

In this sub chapter, we are describing an infrastructure project by defining and understanding the concept project. Next, we are explaining and defining the concept project delivery systems. We do this in order to understand the context of our research question, *"How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?"*.

2.1.1 Infrastructure Project

The concept infrastructure project contains the concept projectwhich we are defining with the help of our reviewed literature. PMI Standards Committee (2008) defines a project as "a temporary endeavour undertaken to create a unique project service or results" (p.434). Similarly, Turner and Downey (1993) present the following definition, "An endeavour in which human, material and financial resources are organized in a novel way, to undertake a unique scope of work, of given specification, within constraints of cost and time, so as to achieve beneficial change" (p.3). From these two definitions, we derive several characteristics: A project is unique, it is temporary, it is subject to a set of restrictions and it aims to create beneficial change. Consequently, we define a project as follows:

> *A project is a way to utilize resources to generate an unique product in order to achieve certain objectives or goals, within a specific set of restrictions.*

A project evolves over time and can therefore be arranged in stages. Figure 1, *Project stages*, shows the stages of a project, also called a project life cycle model. Defining a project life cycle helps to plan, control and to follow up the project (Hussein, 2018). He explains the development of a project as follows: It

starts with the initiation stage whereby the goal and specifications are developed. In the planning phase the detailed specifications, plans and schedules are developed. In the execution and control stage the project is executed, and results are delivered. The last stage, close out, is the stage whereby the project is finished, and the result is transferred to the customer. Thus, in each stage of a project, different work is performed. This can mean that different people will be involved in the different stages. We are explaining in the next paragraph how this applies to an infrastructure project.

Figure 1: Project stages

With the understanding and definition of a project, we can explore the concept infrastructure project. An infrastructure project is a certain type of construction project and is undertaken to build, change or refurbish the infrastructures that surround us. They vary in size and scope, from building a small road in one municipality to multi-billion infrastructure projects that include the building of bridges, railways, highways, stations, etc. Fischer et al. (2017) state that the goal of such projects goes beyond the creation of the structure itself. It is undertaken in order to achieve certain business goals and to create benefits for the public. Thus, the projects must deliver on these requirements throughout its life cycle, from inception through construction and operation to demolition (Fischer et al., 2017). In an infrastructure project there are three main participants who will be involved during the project life cycle. They are necessary to deliver the project from beginning to end. These main participants are the owner, the designer and the contractor (Fischer et al., 2017; Sun et al., 2015). They contribute with their own share to the project. The coordination of the participants within a project will be explained in the next section. Based on the aforementioned, our definition of an infrastructure project

> *An infrastructure project is a project that is undertaken in order to create benefits to the public through the creation of a unique infrastructure product.*

2.1.2 Project delivery system

We have defined an infrastructure project and looked at the different stages. The organizational aspect of an infrastructure project is covered in this section as we are describing the concept project delivery systems.

A PDS describes the relationship between actors, how they are organized and the timing of their involvement within the process of transforming the goals of the project owner into a finished project (ASCE, 2012; Hanna, 2010). In other words, a PDS regulates when and in which processes the different participants should be involved and the relationship between these participants, both with regards to communication and to contractual relations (Fish and Keen, 2012). Engebø et al. (2020c) describe a PDS as follows: "it defines the roles through the procurement route, the sequence of project phases, as well as setting a framework for organisation, roles and responsibilities "(p.279). Similarly, Mesa, Molenaar, and Alarcon (2016) explain a PDS as a strategy that describes the organizational structure of a project and the contractual relationship between the actors with regards to procurement method, compensation method and risk allocation.
Based on the previous, we define a PDS as:

> *a framework that regulates when and how the different actors in an infrastructure project interact with each other, with regards to the organizational structure of the project, procurement method, method of compensation and risk allocation.*

In this sub chapter, we have been able to define an infrastructure project and a PDS. This provides the context of our research question and gives us a foundation for understanding the different types of PDSs that are described in the theory we have reviewed. We will examine these PDSs by dividing them in two categories, Traditional project delivery system (see sub ch. 2.2) and Collaborative Project Delivery System (see sub ch. 2.3). This in order to provide a clear overview and highlight the differences from the traditional delivery methods to the new developed, more collaborative, methods. Hence, to create a better understanding of the ongoing transformation in the AEC industry. This will also enable us to formulate at clear definition of a CPDS which we will continue to use throughout this thesis.

2.2 Traditional Project Delivery

In this sub chapter, we are describing a TPDS in order to understand the difference between a TPDS and the more integrated CPDS as we are explaining in sub chapter 2.3, *Collaborative project delivery*. This understanding is necessary to grasp the context of the challenges that might occur when utilizing a CPDS. We are first describing briefly the most common PDSs that can be placed, in our opinion, in the categorization of TPDS. Thereafter, we are looking at all of them as one entity and are discussing the aspects that make it a TPDS.

2.2.1 Several Traditional Project Delivery Systems

There exists a wide array of different PDSs. We discuss the following three PDSs, Design-Bid-Build (DBB), Construction manager at risk (CMR), and Design-Build (DB), as traditional systems. A DBB is a PDS that separates the design and the delivery phase (Engebø et al., 2020c). It has three main phases. The designing phase (the planning stage in fig. 1), where the owner hires designers who design, specify and plan the project. The bidding phase (stage in between planning and execution control in fig. 1) where contractors give competitive bids on the project and one is chosen to build the project. The third phase is the building phase (the execution control stage in fig. 1), whereby the contractor builds the project (Hasanzadeh et al., 2018).

A project with a CMR model is almost organized in the same way as a DBB, however, a contractor becomes involved during the design phase to provide input. The three parties are still different entities and therefore it can create disputes (Hasanzadeh et al., 2018). The contractor that is involved in the design phase, is not immediately the contractor that build the project either. The project gets up for bid, so if another contractor is more competitive, that contractor is procured to build the project. The DB model hires the designers and contractor as one entity, therefore the disputes can be avoided and the contractor can, besides providing input during the design phase, also "offer a single point of responsibility for construction and design and facilitate fast-track delivery" (Hasanzadeh et al., 2018, p.3).

As can be noticed, the models evolve to be more integrated from DBB, to CMR, to DB, nevertheless we define these three models as TPDSs. DBB is the most common PDS in the AEC industry and is often seen as the archetype of Traditional project delivery systems (AIA California Counsil, 2007; Engebø et al., 2020c; Konchar and Sanvido, 1998). Where as CMR and DB are sometimes considered as alternative methods (Hasanzadeh et al., 2018). Therefore, we are emphasizing a DBB system when we discussing the TPDS further. First, we will look at the process and organization of such a project, next we will look into the amount of integration, and finally we will examine the use of technology.

2.2.2 A Traditional Project Delivery System

As mentioned in the section above, a DBB model has three sequential main phases with a different focus in each phase. "The owner normally contracts with a design company to provide "complete" design documents. The owner or owner agent then usually solicits fixed price bids from construction contractors to perform the work" (Konchar and Sanvido, 1998, p.435). Thus, DBB is characterized by a strict division between the

different phases and the actors are first involved when they are going to perform the actual work (see figure 2), (AIA California Counsil, 2014; Engebø et al., 2020c; Hasanzadeh et al., 2018).

Due to the sequential process or the late involvement of the contractor, the possibility to include the builders expertise within the design phase is eliminated (Hasanzadeh et al., 2018). According to Andary, Abi Shdid, Chowdhury and Ahmad (2019) and Hasanzadeh et al. (2018), this leads to an increased need to do rework and change orders later in the project. As well, Fischer et al. (2017) argue that this leads to lower buildability. Which, according to Hanna (2016), results in increased project duration and cost.

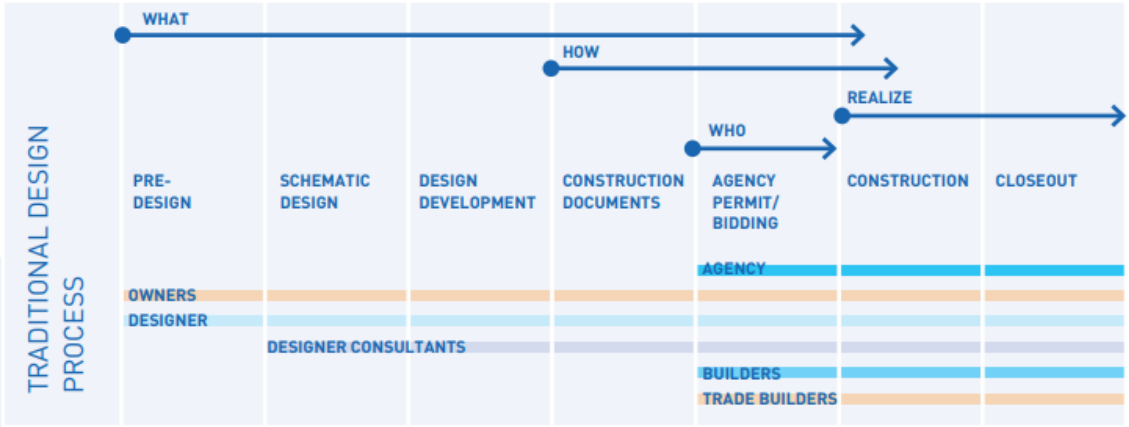


Figure 2: Traditional project delivery system (AIA California Counsil, 2007)

Moreover, the different actors typically engage in separate contracts with the owner (Konchar and Sanvido, 1998). AIA California Counsil (2007) state that this organizing approach contemplates separate silos of responsibility. In other words, it results in a process where the participants specialize within their field of work and are incentivized to optimize only their part of the project, rather than optimizing the project as a whole. In addition, the separate contracts that the owner has with the designer and contractor might have different and even contradictory goals and interest (Hasanzadeh et al., 2018). This and the sub-optimization might affect how well the project achieves project owner's goals (Hussein, 2018). The sequential processing, fragmented relationships and separate goals and interest among project stakeholders can lead to disputes within the project, which have a negative influence on the project with regards to cost increases, delays and work defects (Hasanzadeh et al., 2018). Therefore, the owner has a large degree of responsibility in a TPDS project (Engebø et al., 2020c), such as ensuring that the common goals are met and keeping track on the overall progress of the project (Moradi, Kähkönen, Klakegg and Aaltonen, 2020).

With regards to the use of technology, AIA California Counsil (2007) state that the traditional PDS re-

lies on paper-based and analogue technology. However, this statement is from 2007 and today there is a widespread use of digital technologies, including BIM, in projects that apply a TPDS. Thus, event though traditionally TPDS did not utilize digital platforms, they are now transitioning towards using such tools.

2.2.3 Summary

In conclusion, a TPDS is a delivery system whereby each actor is involved when its contribution should be executed, whereby the owner has separate contracts with the designer and the contractor. These contracts can have unaligned and contradicting goals and interest towards each other and the project. It is expected that the owner has the most responsibility within the project and the other actors are only responsible for their own work. Older literature mentions that TPDSs use paper-based and analogue technology. However due to the widespread use of digital technologies these days, we assess that there has been a transition towards digital tools in TPDSs. The mentioned aspects in this sub chapter lead to challenges which can result in inefficiency. Therefore, more integrated, collaborative systems have emerged. We are discussing these in more detail in the next sub chapter.

2.3 Collaborative project delivery

We have discussed the TPDSs in the previous sub chapter and mentioned that it can result in an inefficient project. Therefore, there has been a need for different methods. This resulted in the creation of new types of PDSs (Engebø et al., 2019). These are characterized by aiming towards a more integrated project team that delivers both the design and the construction (Engebø et al., 2020c) and they provide a framework for integration (Engebø, Klakegg , Lohne and Lædre, 2020b). We can classify these new methods as Collaborative Project Delivery System which we are discussing in this sub chapter.

We are first describing the most known PDS that, in our opinion, can be classified as a full-fledged CPDS. Thereafter, we are looking at all of them as one entity. In addition, we are coming back to the alternative models DB and CMR, discussed in chapter 2.2, as they can be perceived as a hybrid CPDS. We are concluding this sub chapter by formulating a definition of a CPDS which we will use continuously throughout the thesis.

2.3.1 Several Full-Fledged Collaborative Project Delivery Systems

Engebø, Skatvedt, and Torp (2019) argue that the term CPDS has evolved from a generic term into real-life systems like the IPD and Alliancing. Similarly, Lahdenperä (2012) argues that globally there are three

CPDSs that stand out: Project Partnering (PP), Alliancing and Integrated Project Delivery (IPD). We will briefly discuss these as full-fledged CPDSs since they are the most prevalent trends.

PP is described differently in the literature and it is also often mentioned as a multi-facet practice. According to Lahdenperä (2012), the PP method uses documents for improving cooperation and minimizing disagreements, as well as continuous feedback and improvements are key aspects. The documents state the agreed main principles of cooperation, but is not legally binding and it describes the decision-making approach of the project. The actors establish "a project-based temporary coalition through partnering" (Xue et al., 2018, p2). The Alliancing method is widely adopted in Australian infrastructure projects and is defined more clearly than PP. The Victorian Department of Treasury and Finance (2010) captures the definition of an alliancing very well and is as follow:

> *All parties are required to work together in good faith, acting with integrity and making best-for-project decisions. Working as an integrated, collaborative team, they make unanimous decisions on all key project delivery issues. Alliance agreements are premised on joint management of risk for project delivery. All parties jointly manage that risk within the terms of an 'alliance agreement', and share the outcomes of the project (p.9).*

Alliancing emphasizes on creating a shared commitment towards the success of the project (Hauck, Walker, Hampson, and Peters 2004) manifested recently through a multi-party contract with joint liability (Department of Treasury and Finance, 2010c). As well as a high level integration between the actors is a necessity for an alliance to succeed (Hauck et al., 2004). Where Chen, Zhang, Xie, and Jin (2012) argue that a project proposal should be developed with all parties and thus imply that early contractor involvement is an important aspect in Alliancing. The IPD method originates from America and has the following definition, given by AIA California Counsil (2014):

> *A project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction (p.4).*

The aspects of IPD that are frequently mentioned in the literature are early involvement of stakeholders, multi-party contracts, a concurrent process, risk sharing, profit sharing, and the use of technology for visualization and simulation (AIA California Counsil, 2007, 2014; Andary et al., 2019; Fischer et al., 2017; Hanna, 2016; Mesa et al., 2016).

As can be noticed, the elements in the three PDSs are similar. According to Lahdenperä (2012) they originate from the same trend. They have had a mutual influence on each other, but have developed slightly different due to geographical factors. Some argue that Alliancing is the Australian version of CPDS and IPD is the American version (Engebø et al., 2019; Lahdenperä, 2012). Since they are similar to each other, we will treat them as one entity. We will first discuss the process and organization of such a project system, next we are looking into the amount of collaboration and finally we examine the use of technology within these PDSs.

2.3.2 A collaborative Project Delivery System

One of the key elements in a full-fledged CPDS is the contract type. AIA California Counsil (2007) explain a multi-party agreement as one single contract for the core group which specifies roles, rights, obligations and liabilities. By using a multi-party agreement the core group share liability. This means that they share the benefits and risks (Aapaoja, Herrala, Pekuri and Haapasalo, H,2013; AIA California Counsil, 2007).

Another key element is collaboration among the participants within such PDS. The project team has to work together to achieve project goals. Roles, responsibilities and (expected) relationships between partners can be defined within the multi-party agreement (AIA California Counsil, 2007). However, to collaborate together, a team needs more than just a contract. AIA California Counsil (2007) and Fish and Keen (2012) are explaining that the group need to trust and respect each other, and know that each and one of them work to the projects interest and not their individual interest, so transparency is needed which can be achieved open communication (AIA California Counsil, 2007; Chen et al., 2012). Hauck et al. (2004) state that it requires ”excellence in communication at a personal level, at a business level, and at operational level” (p.145), and thus suggest that communication among all participants is very important. In addition, Chen et al. (2012) argue that decisions should be made collaboratively and that each participant should have an equal say in the decisions.

The collaboration within a CPDS becomes also more important due to another perceived key element, which is early contractor involvement (ECI). ECI is the involvement of the contractor from the early phases, or at least the design phase. This means that the three main participants form the core group from the beginning of the project (AIA California Counsil, 2007; Ghassemi and Becerik-Gerber, 2011; Kent and Becerik-Gerber, 2010; Lahdenperä, 2012; Roy et al., 2018). This changes the roles and relationships of the key participants

(Fish and Keen, 2012; Hanna, 2016). However, Andary et al. (2019) state that the early involvement is a necessity as it promotes well-developed relationships, since the participants get to know each other and gain understanding of each others profession (Engebø et al., 2020b) which supports that collaboration is necessary. AIA California Counsil (2007) provide a good visualization of the involvement of the participants when using ECI. Their model can be found in figure 3, *Collaborative Project Delivery Systems (AIA California Counsil, 2007)*.

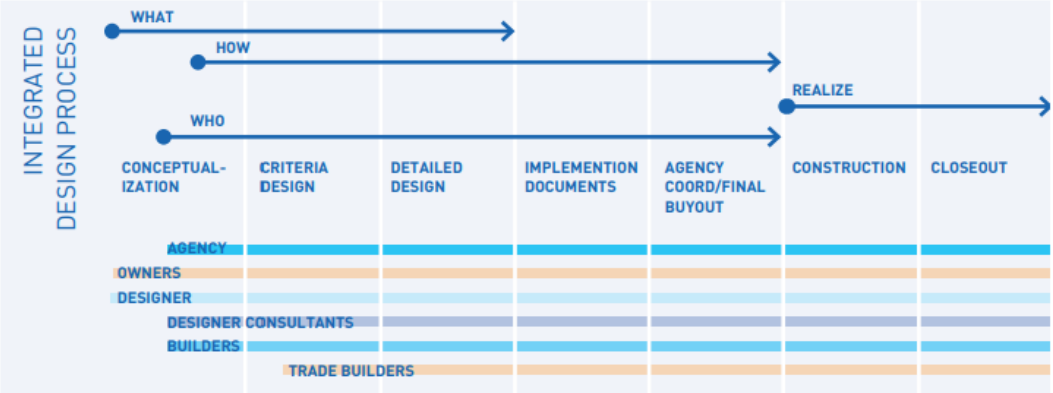


Figure 3: Collaborative Project Delivery Systems (AIA California Counsil, 2007)

The last element that is perceived as a key enabler for a CPDS, in our reviewed literature, is technology. As Hauck et al. (2004) state, "[the excellence in communication] requires a quantum leap in the use of shared information technology systems and information processing integration (p.145)". As well as AIA California Counsil (2007) argue that most CPDSs are dependent on the use of technology to support collaboration and that not using technology would violate the principle of optimizing the project. Similarly, Fischer et al. (2017) state: "simulations and visualisations enable the team members to share their knowledge effectively, try out design ideas, separate fact from fiction, contrast good solutions with poor solutions, and communicate with other team members and stakeholders (p.32)." This all suggest that technology is a necessity since it enhances collaboration and communications among the participants.

2.3.3 Hybrid Project Delivery Systems

The above mentioned elements are not all necessary to create a more efficient and integrated process. As mentioned in sub chapter 2.2, *Traditional Project Delivery*, DB and CMR are seen as alternative methods (Hasanzadeh et al., 2018). According to Mollaoglu-Korkmaz, Swarup and Riley (2013), these two methods can provide integration, and thus an efficient project, when they facilitate ECI. This is also supported by Engebø et al. (2019) and Hanna (2016), who refer to this trend as Near IPD or IPD-ish. Integration by the

means of ECI and the extensive use of technology would create an efficient project as well. We will refer to such systems as Hybrid project delivery systems, or in short Hybrids.

Hybrids utilizes the elements associated with IPD and Alliancing within the context of other PDS such as DB and CMR (Engebø et al., 2019; Hanna, 2016; Mollaoglu-Korkmaz et al., 2013). The elements that are used in these cases are ECI, extensive collaboration and often they use technology platforms to enhance this collaboration. However, the multi-party contract often conflicts with local procurement law (Ghassemi and Becerik-Gerber, 2011; Kim, Rezqallah, Lee and Angeley, 2016). To eliminate this conflict, Kim et al. (2016) suggests the use of a hybrid method, where this contract is left out.

Thus, when we remove the contractual element of a full-fledged CPDS, hence eliminate the challenges and risks related to a multi-party agreement, we are left with the three main elements; ECI, Collaboration and Technology, which we indicate as a necessity to create an integrated and efficient project. This leads to the following definition of a Hybrid PDS:

> *A PDS that aims to harness the benefits of a full-fledged CPDS through an extensive emphasis on early involvement of the contractor, collaboration between the participants and the use of technology to enhance communication and collaboration within the frames of the local procurement law and practises.*

2.3.4 Summary

In conclusion, a full-fledged CPDS utilizes the four elements; multi-party agreement, ECI, Collaboration and Technology. However, some argue that the multi-party agreement is not a necessity which leaves us with a Hybrid CPDS. This is a PDS with the foundation of a DB or CMR which utilizes the element ECI. We have now explained the different PDSs that are addressed in the existing theory. we will summarize the different elements of the PDSs in the next sub chapter to create a clear overview of the differences between a TPDS (see sub ch. 2.2), a full-fledged CPDS (see section 2.3.2 and Hybrids (see section 2.3.3).

2.4 Overview of product delivery systems

In sub chapter 2.2, *Traditional Project Delivery*, we explained the elements of a TPDS. In short, a TPDS is a model whereby the owner has the most responsibility and has separate contracts with the designer and contractor whom are involved in the project when their contribution has to be executed. In sub chapter 2.3,

Collaborative project delivery, we discussed different forms of a CPDS. We examined the most prevalent CPDS trends: PP, IPD, and Alliancing as well as Hybrids. PP, IPD and Alliancing are full-fledged PDSs that include multi-party contracts that are developed specifically for these PDSs.

As mentioned in section 2.3.1,*Several Full-Fledged Collaborative Project Delivery Systems*, and 2.3.2,*A collaborative Project Delivery System*, the main characteristics of thesePDSs include risk sharing, reward sharing, early contractor involvement, collaboration between the participants, the use of technology to enhance collaboration and communication. However, as mentioned in section 2.3.3, *Hybrid Project Delivery Systems*, Engebø et al. (2019) and Hanna (2016) argue that it it possible to achieve a high amount of the benefits of the full-fledged systems, by utilizing some of the principles, within the frames of local procurement regulations and other PDSs. We summarized the characteristics of the different PDSs in table 1, *Overview of the elements of the different PDSs*. This table presents an overview of the similar and different characteristics of the PDSs.

	TPDS	**CPDS**	**Hybrid**
Multi-Party Agreement	No	Yes	No
Risk Sharing	No	Yes	No
Reward Sharing	No	Yes	No
Early Contractor Involvement	No	Yes	Yes
Focus on Collaboration between all participants	No	Yes	Yes
Leveraging digital and 3D technology	No*	Yes	Yes

Table 1: Overview of the elements of the different PDSs

This chapter creates an good understanding onPDSs and their differences. We only miss a common definition on a CPDS which we can use for our research as this lacks in the existing theory. Based on this chapter and thus the table above, we define a CPDS as:

> *A project delivery system that aims to improve the efficiency of projects through early contractor involvement, collaboration between participants and utilizing technology to enhance communication and collaboration. They may utilize specialized contracts, but can also exist within existing standards of local procurement laws.*

This is the definition we will use throughout our thesis for a CPDS. This definition shows that we identified three elements, ECI, Collaboration and Technology, as important for a collaborative project. In order to

emphasize these elements in our research, we have developed the following sub research questions:

- *How does the use of ECI influence collaborative infrastructure projects in Norway?*
- *How does collaboration influence collaborative infrastructure projects in Norway?*
- *How does the use of technology influence collaborative infrastructure projects in Norway?*

These sub research questions are giving us focus and are narrowing the scope of this thesis. The answer to these questions will also create a solid foundation for answering the overall research question, *"How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?"* In figure 4, *The ECT framework foundation*, we visualized the scope of our thesis based on this chapter. It is a base framework that we are detailing and revising throughout this thesis.

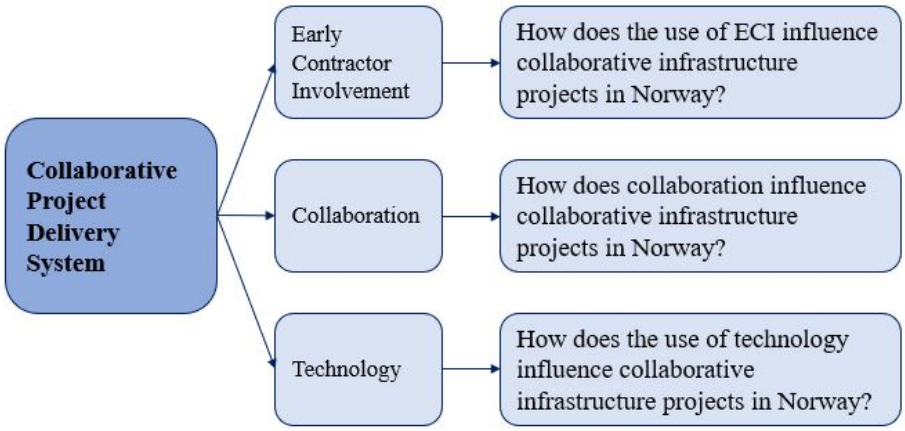


Figure 4: The ECT framework foundation

We have now established a focus for a thorough literature review to identify the challenges that can occur when implementing a CPDS. In the next chapter we are examining these challenges.

3 Challenges with Collaborative Project Delivery

In sub chapter 2.4, *Overview of product delivery systems*, we introduced three sub research questions related to the three main elements of a CPDS. These elements are the foundation of integration and, therefore, necessary for implementation of CPDS (Engebø et al., 2020a). In this chapter we are discussing the challenges related to these three elements on a theoretical level. This discussion will form the theoretical foundation for our case study and our answer to the sub research questions. Subsequently, this will enable us to answer our main research question, *"How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?"* The chapter will start by presenting an overview of the challenges that we identified during our literature review. In the following sub chapters, we are addressing the identified challenges. The sub chapter will be structured after the ECT framework. Each sub chapter is concluded with theoretical propositions. Finally, we are concluding the chapter by complementing our ECT framework with the suggested propositions. This will form the foundation of our case study.

Challenges review

We performed an intensive literature review to reveal the challenges and how to overcome them in the existing literature. We searched for articles that included one of the main elements, thus ECI, Collaboration and Technology, together with collaborative project management, IPD, challenges and/or barriers. In addition to the searches, we used revers snowballing to follow trails of interest in the articles.

During our review we noticed that the main elements could be categorized even further. Two of our selected articles have categorized challenges related to implementing IPD as well, namely Roy et al. (2018) and Kahvandi, Saghatforoush, Mahoud and Preece (2019). They have given us the idea to categorize the the main elements to smaller elements. However, we have performed the search to challenges ourselves as well as the sub categorization is suggested by us. An extensive table with the three main elements, the sub categories, the related challenges and the author whom discusses that specific challenge can be found in the appendix A, *Challenges*. A summarized table is provided in table 2, *Challenge review*.

Category	Subcategory	Sources
Early Stakeholder Involvement	General	Engebø et al. (2020b), Durdyev et al. (2020), Rahmani (2020)
	Team forming	Aapaoja et al. (2013), AIA California Counsil (2014), Becerik-Gerber and Kent (2010), Butt et al. (2016), Ebrahimi and Dowlatabadi (2018), Engebø et al. (2020b) Ghassemi and Becerik-Gerber (2011), Rahman and Alhassan (2012), Roy et al. (2018)
	Project Definition	Aapaoja et al. (2013), Becerik-Gerber and Kent (2010), Butt et al. (2016), Durdyev et al. (2020), Ebrahimi and Dowlatabadi (2018), Engebø et al. (2020b), Fish and Keen (2012), Ghassemi and Becerik-Gerber (2011), Hoezen (2012), Rahman and Alhassan (2012), Roy et al. (2018)
	Role Restructuring	Abdirad and Dossick (2019), Azhar et al. (2014), Ebrahimi and Dowlatabadi (2018), Fish and Keen (2012), Ghassemi and Becerik-Gerber (2011), Rahmani (2020), Whang et al. (2019)
Collaboration	Communication	Aapaoja et al. (2013), Azhar et al. (2014), Butt et al. (2106), Durdyev et al. (2020) Rahman and Alhassan (2012), Shen et al. (2010)
	Trust	Aapaoja et al. (2013), Andary et al. (2019), Alves and Shah (2018), Durdyev et al. (2020). Engebø et al. (2020a), Fish and Keen (2012), Ghassemi and Becerik-Gerber (2011), Ilozor and Kelly (2012), Kahvandi et al (2017), Rahman and Alhassan (2012), Roy et al (2018), Sun et al. (2015)
	Motivation	Aapaoja et al. (2013), Alves and Shah (2018), Azhar et al. (2014), Durdyev et al. (2020), Ebrahimi and Dowlatabadi(2018), Engebø et al. (2020b), Kahvandi et al. (2017), Kent and Becerik-Gerber (2010), Rahman and Alhassan (2012), Rahman and Alhassan (2012), Rahmani (2020), Roy et al. (2018)
Technology	Interoperability	Azhar et al. (2014), Becerik-Gerber and Kent (2010), Durdyev et al. (2020), Ghassemi and Becerik-Gerber (2011), Roy et al. (2018), Shen et al. (2010)
	Inexperience	Becerik-Gerber and Kent (2010), Ebrahimi and Dowlatabadi (2018), Kapogiannis and Sherrat (2018), Moreno et al. (2019), Rahman and Alhassan (2012), Svalestuen et al. (2017)

Table 2: Challenge review

In the following sub chapters, we are discussing the challenges found in the challenge review.

3.1 Early Contractor Involvement

In this sub chapter we are addressing early contractor involvement which is the first element of the ECT framework. We will lay the foundation for answering the sub research question *"How does the use of ECI influence collaborative infrastructure projects in Norway?"* In sub chapter 2.2, *Traditional Project Delivery*, we explained that in a project utilizing TPDS, the participants of a team are involved in the project when they need to perform their tasks (AIA California Counsil, 2014; Engebø et al., 2020c). In sub chapter 2.3, *Collaborative project delivery*, we explained that in a project utilizing CPDS, the participants are involved from the beginning of the project (AIA California Counsil, 2007; Ghassemi and Becerik-Gerber, 2011; Kent and Becerik-Gerber, 2010; Lahdenperä, 2012; Roy et al., 2018) in order to integrate the contractor's expertise in the design phase (Lloyd-Walker, Mills and Walker, 2014). In general, the contractor or the owner can be hesitant to early contractor involvement due to high initial cost and risk (Engebø et al., 2020b; Durdyev, Hosseini, Martek, Ismail and Arashpour, 2020; Rahmani, 2020) or because they are unfamiliar

with ECI (Rahmani, 2020). However, some advocate that early involvement is a requirement to create a well-functioning integrated team and efficient collaboration (Engebø et al., 2020b; Heravi, Coffey and Trigunarsyah, 2015). The organization of the project and the contribution of each participant to the project changes due to early involvement of all participants (Abdirad and Dossick, 2019; Whang et al., 2019). This change can give challenges that need to be overcome for an CPDS to provide its potential benefit.

In this sub chapter, we categorized the challenges related to ECI in three sub categories; team forming, project definition and role restructuring.

3.1.1 Team Forming

Involving the contractor early can leverage the common knowledge pool to maximize the value creation of the project (Aapaoja et al., 2013; Engebø et al., 2020b). Nevertheless, the project team should be an integrated team (Rahman and Alhassan, 2012) that consists of capable and committed participants with the right expertise and the right knowledge to exploit this potential (Aapaoja et al., 2013; Ebrahimi and Dowlatabadi, 2018; Ghassemi and Becerik-Gerber, 2011). However, it can be a challenge to form such a team (Ghassemi and Becerik-Gerber, 2011) due to inexperience with CPDS among the participants in the industry (Ebrahimi and Dowlatabadi, 2018; Roy et al., 2018). Besides the challenge of finding the right key participants in terms of a contractor and a design firm, it is also necessary to have a competent and risk tolerant owner (Roy et al., 2018) who has expertise in team formation and team building (AIA California Counsil, 2007). However, (Engebø et al., 2020b) emphasize that the project team should have autonomy and the authority to make decisions within the project. Ghassemi and Becerik-Gerber (2011) also argue that the owner should select a team based on quality instead of costs. We assume that a competent owner is able to form a good team and to look further than only low cost and thus competency of the owner is an important aspect.

Kent and Becerik-Gerber (2010) mention that establishing the right team early on is important because it can avoid fragmentation between the contractors and designers, and indirectly lead to a more efficient project. Ghassemi and Becerik-Gerber (2011) also state that involving members late in the process can give issues. Losing or replacing key participants can have a negative impact on the collaboration and communication within the project (AIA California Counsil, 2007; Butt, Naaranoja, and Savolainen, 2016; Engebø et al., 2020b). Involving participants later in the process, either by late involvement or replacement, can lead to a lack of integration of the team which is not beneficial for the collaboration (Rahman and Alhassan, 2012). In addition to forming the team with the key participants, it can be a challenge to know when to

involve the subcontractors (Roy et al., 2018). They explain that their expertise can be useful, but they might not be as reliable as the key participants and thus a balance of involvement should be found.

The theory in this section emphasizes that the creation of the project team with competent participants is an critical factor when using ECI (Aapaoja et al., 2013; Ebrahimi and Dowlatabadi, 2018). Some authors argue that a risk tolerant owner with expertise in team forming is the most important to establish such team (AIA California Counsil, 2007). Based on this we propose: **Proposition E1: The owner's ability to form a good team is important in projects that utilize Early Contractor Involvement**

3.1.2 Project Definition

A project simplified has four stages, as mentioned in sub chapter 2.1.1, *Infrastructure Project*. In the initiation and planning stage the project goal, scope, specifications, budget, plan, responsibility, and accountability are defined (Hussein, 2018; Ghassemi and Becerik-Gerber, 2011). Kent and Becerik-Gerber (2010) and Roy et al. (2018) stress the need of early definition of project goals in a project. Also Hoezen (2012) state that it is important that the project content and customer requirements are perceived well. This can be related to the necessity of a competent owner (see section 3.1.1) who can provide a good project definition (Ghassemi and Becerik-Gerber, 2011) and the need for good communication from the owner (see section 3.2.1). When the owner is inexperienced with the process of a CPDS it can be a challenge to provide a good project definition (Fish and Keen, 2012). When the contractor gets involved early, there is a need to merge needs and objectives (Aapaoja et al., 2013), so the organization of the project changes and thus the specifications and responsibilities. This leads to an increased need for a clear project definition to ensure agreement and understanding of the project among all participants (Aapaoja et al., 2013; Ebrahimi and Dowlatabadi, 2018; Hoezen, 2012; Roy et al., 2018). Ebrahimi and Dowlatabadi (2018) explain that making decisions which are clear and on time are important. Nonetheless, Butt et al. (2016) explain that the decision making process can be unclear in project. A reason for this can be unclear or late decision making by the owner (Durdyev et al., 2020). Another reason can be that, due to shared decision making, it is unclear who has the authority to make the final decision (Engebø et al., 2020b). In addition to the decision making process, the allocation of responsibility within the project team can be unclear (Ebrahimi and Dowlatabadi, 2018; Rahman and Alhassan, 2012).

Thus, this suggests that there is a general agreement in the existing theory that it is important for an owner to be able to define and communicate the project specifications clearly in order to transfer the owner's visioned

needs and goals of the project. The specifications are regarding the project goals, budget, quality expectations, scope, planning, decision making process, roles, responsibility as well as ensure that all participants share the understanding of the perspective of the project value (Aapaoja et al., 2013). Based on this we propose: **Proposition E2: The creation of a good project definition is important in projects that utilize Early contractor involvement.**

3.1.3 Role Restructuring

Due to the early involvement of the contractor, the roles of the participants change in the project process (Abdirad and Dossick, 2019; Ebrahimi and Dowlatabadi, 2018; Whang et al., 2019). The role restructuring makes the project more flexible, however the project success can be restrained when the participants are not able to accept or adapt to the restructured roles (Whang et al., 2019). Abdirad and Dossick (2019) explain that restructuring the role of the architect will give them more engineering and construction responsibility. While Heravi et al. (2015) explain that the restructuring for the contractors means that they have to act more as a developer rather than a contractor in the early phases of the project. This requires a change in mindset from the traditional way of working (Azhar, Kang, and Ahmad, 2014) which is a challenge related to motivation (see section 3.2.3). In addition to role restructuring, Azhar et al. (2014) state that work processes and relationships change. The latter is supported by Rahmani (2020), who explains that there is a change in the relationship protocol due to ECI. The restructuring of roles and the process should be discussed by the participants until an agreement is reached(Abdirad and Dossick, 2019). One should keep in mind that the restructuring and sharing of roles does not mean that the responsibility of each task is also shared. Each participant will have responsibilities of their own with a focus on their traditional role (Abdirad and Dossick, 2019).

Abdirad and Dossick (2019) and Fish and Keen (2012) mention that another role might be necessary, the facilitator role, during all stages of the project. A facilitator is guiding and informing the group about the utilized CPDS and its elements, such as ECI Fish and Keen (2012). This role can be useful when participants are inexperienced and need guiding to create an efficient project by collaborating together. It can be fulfilled by an external party or by one of the key participant whom has experience. In that case all participants should be able and willing to take on the facilitator role when required (Fish and Keen, 2012). However, a CPDS is not designed to have the facilitator role and therefore it can be challenging to include this role when necessary (Fish and Keen, 2012; Ghassemi and Becerik-Gerber, 2011).

There seems to be an agreement in the theory that involving more participants in the early phases means that they will have to engage in new activities (Abdirad and Dossick, 2019; Heravi et al., 2015). As a result the project participants might experience that they need adapt to new roles. These roles should be discussed openly until there is an agreement on the new roles (Abdirad and Dossick, 2019). Based on this we propose that: **Proposition E3: Early contractor involvement leads to a restructuring of the traditional roles.** This restructuring can be challenging for participants that are inexperienced with this way of working in project teams. Fish and Keen (2012) and Abdirad and Dossick (2019) state that the inclusion of a facilitator, either internal or external, may ease the transition. Thus, we propose that: **Proposition E4: A facilitator will ease the transition to a CPDS in a project where the participants are inexperienced with the required way of working.**

3.2 Collaboration

In this chapter we are discussing collaboration which is the second element in the ECT framework. This discussion will provide a theoretical base for answering the sub research question *"How does collaboration influence collaborative infrastructure projects in Norway?"*

When all participants collaborate successful with each other, the outcome of a project can become better (Olander and Landin, 2005). In the construction industry, and thus for infrastructure projects, collaboration is very important because of their interdisciplinary nature (Sun, Mollaoglu, Miller and Manata, 2015). Collaboration has various forms and can be defined in different ways. A basic definition is people working together on a project towards an jointly, agreed goal (AIA California Counsil, 2014; Moradi et al., 2020). In TPDSs each participant optimizes their own benefits and minimizing their own risk, there are no incentives for collaboration (Aapaoja et al., 2013), as explained in sub chapter 2.2, *Traditional Project Delivery*. On the contrary, a CPDS needs collaboration, such as information sharing, to be able to integrate the project (Engebø et al., 2020c; Fischer et al., 2017). Challenges can arise due to the increased need for collaboration in a CPDS (Alves and Shah, 2018).

Aapaoja et al. (2013) argue that the rational and incentive for collaborating only can be understood when the process and nature of a PDS is understood. Hasanzadeh et al. (2018) confirm this and say that it should be understood by all participants to minimize the level of disputes within the project. In order to see what enables collaboration, we are looking deeper into collaboration and its elements, before discussing the challenges related to it. Our selected literature is somewhat divided about the requirements to establish collabo-

ration. AIA California Counsil (2014) argue that collaboration requires respect, trust, integration, and joint liability. Sun et al. (2015) argue that collaboration is a consequent of effective communication. According to Fischer et al. (2017), a project team's culture in an CPDS is based on cooperation, trust, teamwork and effective communication. Kent and Becerik-Gerber (2010) includes that technical tools can increase the efficiency of collaboration, however it is not a necessity. Based on our selected literature and our project thesis, we divided the challenges related to collaboration into three sub categories; communication, trust and motivation.

3.2.1 Communication

Communication is the ability to listen to others, to openly express feelings, ideas and opinions and to read non-verbal cues (Moradi et al., 2020). Clear, direct, open, transparent, and trusting communication between participants is an important element in a CPDS (AIA California Counsil, 2007). Communication can enhance problem solving during all phases in a project (Hamzeh et al., 2019). It also enables information transfer and shared understanding of the project between all participants (Aapaoja et al., 2013; Kapogiannis and Sherratt, 2018) which leads to consensus and satisfaction among them (Abdirad and Dossick, 2019; Hoezen, 2012). Consequently, this can lead to a more efficient project.

It can be a challenge to establish good communication, which is continuous, open and honest, whereby all participants are satisfied (Ebrahimi and Dowlatabadi, 2018; Rahman and Alhassan, 2012). A lack of communication and thus a lack of information sharing can lead to an inefficient project (Butt et al., 2016; Durdyev et al., 2020), as well as an overflow of information or ineffective communication of information can lead to inefficiency (Butt et al., 2016).

When participants are unfamiliar with each other and thus have a poor relationship, enabling communication can be a challenge (Durdyev et al., 2020). Therefore, the participants should become familiar with each other. The literature state various options to implement as an individual means to establish open communication among the participants. Defining a communication protocol for a good information flow is one of these measures to describe what communication is expected (AIA California Counsil, 2007; Butt et al., 2016), where as co-location is introduced as a means to increase communication, familiarity and interaction (AIA California Counsil, 2007; Aapaoja et al., 2013; Alves and Shah, 2018; Engebø et al., 2020a; Fischer et al., 2017; Ghassemi and Becerik-Gerber, 2011), as well as kick-off meetings are suggested to establish relationships and communication (Engebø et al., 2020b,a). In addition, technology can enhance efficient

communication as well as project understanding, when integrated among all participants within the project (Azhar et al., 2014; Engebø et al., 2020b; Shen et al., 2010; Kapogiannis and Sherratt, 2018). Merschbrock and Munkvold (2015) argues that technology can even replace the measure of co-location, because participants can work together from a distance. This would mean that technology can overcome the barrier of co-location not being realistic for everyone, as (Aapaoja et al., 2013) state.

Thus, an infrastructure project needs communication that is open, honest, continuous and presented in an understandable manner for all participants to be efficient (Aapaoja et al., 2013; AIA California Counsil, 2007). The literature suggest different individual manners to establish open communication, such as implementing communication protocols (Butt et al., 2016), co-location (Aapaoja et al., 2013), kick-off meetings (Engebø et al., 2020b) or utilizing technology (Azhar et al., 2014). Open communication is perceived as an important element of a CPDS with various means to be established. Therefore, we propose that:
Proposition C1: The use of measures to enhance open communication is necessary to establish collaboration.

3.2.2 Trust

Our literature stresses the necessity of trust within a project team and that a lack of trust can be a challenge of implementing a CPDS (AIA California Counsil, 2007, 2014; Andary et al., 2019; Engebø et al., 2020a; Fish and Keen, 2012; Ghassemi and Becerik-Gerber, 2011; Ilozor and Kelly, 2012; Kent and Becerik-Gerber, 2010; Rahman and Alhassan, 2012; Roy et al., 2018). Pinto, Slevin and English (2009) explain trust as believing in someone's competence, ability and dependability to perform a task. Thus, trust in a project is trusting that all participants are working to the best possible outcome, the shared goal, and not their individual interest (Aapaoja et al., 2013). Hence, it can create mistrust when participants keep working towards their own interest, as in a TPDS (Alves and Shah, 2018). Participants should be able to see the capabilities of the others and each and one of them should be transparent to gain each others trust (AIA California Counsil, 2014; Andary et al., 2019; Ghassemi and Becerik-Gerber, 2011). To ensure this, AIA California Counsil (2007) suggest that the participating firms should share both risks and rewards, as this links the projects interest with the interest of the individual firm, and in so enables trust.

We indicate that there are two kind of trust expressed in the theory, which we label as contractual and relational trust. The contractual trust is the trust that is explained by AIA California Counsil (2007), which is imposing trust through shared risk and rewards or by incentives. Relational trust is established over time

(Aapaoja et al.,2013; Kahvandi, Saghatforoush, Alinezhad and Noghli, 2017) and experience together (AIA California Counsil, 2014; Sun et al., 2015), something that most project teams do not have. Ghassemi and Becerik-Gerber (2011) and Andary et al. (2019) both explain that there are two forms of this relational trust. One that builds up over time and that exist in project where team members have previous worked together, preexisting trust. The other one is described as forced trust, which is trust that gets created by means of collaboration tools and activitiesGhassemi and Becerik-Gerber (2011), such as co-location (Engebø et al., 2020b,a; Ghassemi and Becerik-Gerber, 2011) and kick-off meetings (Engebø et al., 2020a). This forces participants to work closely together, communicate openly and share information which can increase trust because they become more familiar with each other (Aapaoja et al., 2013; Butt et al., 2016; Durdyev et al., 2020). Engebø et al. (2020a) and Kent and Becerik-Gerber (2010) support that processes in a project and collaboration rely on relational aspects and, therefore, trust is a necessity, rather than the contractual aspects which AIA California Counsil (2007) suggest.

Trust can be build over time and it can be challenging within a project that does not have this (Aapaoja et al., 2013). Trust is an important element of collaboration and will ensure participants that they all work towards the shared project goal. With use of tools and activities trust can be forced onto participants. Co-location and kick-off meetings can be such activities that enhances communication, information sharing and understanding of each others work processes, and thus trust (Engebø et al., 2020a; Kent and Becerik-Gerber, 2010). As well as incentives and shared risks can impose trust (AIA California Counsil, 2007). Based on the previous, we asses that there is an agreement, in the theory, that trust is important to establish collaboration within a project team. Consequently, we propose the following: **Proposition C2: Building trust among the participants is vital to enable collaboration.**

3.2.3 Motivation

Communication and trust are important elements to collaborate. To be able to establish these two, commitment and willingness to the project, in other words motivation, is a necessity. Motivation is the inclination of participants to collaborate in a project (Ghassemi and Becerik-Gerber, 2011). Engebø et al. (2020b) argue that collaboration does not happen because contracts content states that it should, but the participants should be committed and motivated during the entire project. Kent and Becerik-Gerber (2010) add that monetary incentives are not enough to motivate participants to collaborate. However, Aapaoja et al. (2013) warns that it should not be underestimated. Motivation can be concerned with different aspects of the project which we will look at in this section.

A CPDS requires a different way of working and collaborating than traditional projects and therefore, participants need to be acceptant and willing to embed CPDS elements (AIA California Counsil, 2007; Azhar et al., 2014; Ebrahimi and Dowlatabadi, 2018; Roy et al., 2018). Some project members are not suitable to work in a project with these requirements (Aapaoja et al., 2013). They can lack the spirit to collaborate (Durdyev et al., 2020). The spirit of collaboration is the willingness to communicate (Azhar et al., 2014), to cooperate (Kahvandi et al., 2017) to trust (Azhar et al., 2014) as well as willingness to resolve disputes (AIA California Counsil, 2007). Other reasons for not being motivated to collaborate can be lack of understanding and awareness the CPDS elements and its benefits (Aapaoja et al., 2013; Kent and Becerik-Gerber, 2010; Kahvandi et al., 2019; Roy et al., 2018). Whereby the involvement, understanding and motivation of the owner to utilizes a CPDS is especially important (Azhar et al., 2014; Engebø et al., 2020b; Kent and Becerik-Gerber, 2010). Another reason can be that participants are not willing to change their traditional mentality (Aapaoja et al., 2013; Durdyev et al., 2020; Ebrahimi and Dowlatabadi, 2018; Rahmani, 2020). It can also be that there is a lack of incentives to collaborate (Aapaoja et al., 2013; Alves and Shah, 2018; Rahman and Alhassan, 2012). According to Ebrahimi and Dowlatabadi (2018) and **?**, the team members should also be individual compatible to communicate, trust and share information. This is also briefly mentioned by AIA California Counsil (2007). An extreme solution for personal compatibility is replacing individuals in a team. However, this is not beneficial for the team integration and collaboration in a project (Engebø et al., 2020a).

Kahvandi et al. (2017) explain that motivation can be strengthened when the definition process is done in the early phases. In addition, active involvement and commitment in the decision making processes can show motivation towards the project (Abdirad and Dossick, 2019; Roy et al., 2018). When mutual trust is established among the participants, they are more likely to be committed to the project goals since they know that all participants are committed to those (Aapaoja et al., 2013). Based on the previous we assess that by working close together it is possible to discover if individuals are compatible. As well, it can lead to more experience with each other, create more understanding of the project and it can show each participant one another's way of working. This can create trust and enables willingness to collaborate, communicate and sharing information with each other. Therefore, co-location and kick-off meetings could be a way to overcome the challenge of motivation.

Thus, motivation is necessary to commit to the increased need for collaboration in a CPDS(Azhar et al.,

2014). It can be created by active involvement in the decision making (Abdirad and Dossick, 2019; Roy et al., 2018), early project definition, shared understanding of the project and trust in each others work processes (Aapaoja et al., 2013). It is also indicated that it is important that the participants are willing to adapt a more collaborative mentality (Aapaoja et al., 2013), that enables them to communicate, trust and share information with each other. Based on this we propose the following: **Proposition C3: Motivation is necessary to establish collaboration.**

3.3 Technology

In this sub chapter we are discussing the third element of the ECT framework, technology. This discussion will form the theoretical foundation for answering the sub research question *"How does the use of technology influence collaborative infrastructure projects in Norway?"*

The literature takes two different perspectives on the utilization and benefits of technology. Engebø et al. (2020b), Moreno, Olbina, and Issa, 2019 and Kapogiannis and Sherratt (2018) say that it enhances collaboration and communication within the project. However, Wang, Thangasamy, Hou, Tiong and Zhang (2020) and Kent and Becerik-Gerber (2010) take a different standpoint and say that the promised benefits of technology can be obtained in a collaborative environment due to aligned goals and focus on project success. Due to this requirement of collaboration, CPDS can use technology most effectively (Kent and Becerik-Gerber, 2010). Kent and Becerik-Gerber (2010) also mentions that technology is not a prerequisite for utilizing CPDS. However, Shen et al. (2010) argue that system integration is a key enabler for productivity and efficiency in the construction industry and thus supports using integrated technology within an infrastructure project. With these perspectives taken in consideration, we assume that a technology platform, such as BIM, can enhance more efficient collaboration, provided that collaboration is already established. However, the implementation of new technology platforms also introduces new challenges. We divided the challenges of utilizing technology into two categories, interoperability and inexperience and we are discussing these in this sub chapter.

3.3.1 Interoperability

An infrastructure project has different participants in their core group and they all have to communicate, share information and work on the same project. Technology, such as digital platforms and software can enhance their work processes as well as their communication when they are interoperable Azhar et al. (2014). However, the participants require different functions within their IT systems as well as they have different

accessibility (Azhar et al., 2014). This leads to different utilized digital systems among the participants which are not interoperable. A lack of interoperability is a challenge in an infrastructure project (Ghassemi and Becerik-Gerber, 2011; Roy et al., 2018; Shen et al., 2010) since it takes time to transfer data between systems as well as information can get lost during the information transfer between two different systems. The latter leads to disruption in communication. Ebrahimi and Dowlatabadi (2018) say that projects only reach partial integration with digital collaboration technologies. This means that the potential benefits that technology can provide is not reached within the infrastructure industry yet.

Our reviewed literature reasons different possibilities for creating interoperability. Ghassemi and Becerik-Gerber (2011) argue that their is a lack of technology within the industry. Kent and Becerik-Gerber (2010) adds that the technology is not advanced enough yet. This means that a digital platform available for all participants which satisfy the needs and requirements of each and one of them, could create interoperability within the infrastructure industry. However, such a technology does not exist yet. Furthermore, clear technology standards should be set (Roy et al., 2018) or digital information management protocols should be demanded (Azhar et al., 2014) within a project. This can lead to better utilization of technology (Durdyev et al., 2020) and interoperability would be established since the participants have to work with the systems that are specified.

A collaborative project can benefit by the use of technology when utilized and integrated as a whole between the different participants. When it is interoperable it can enhance communication and information sharing, and thus collaboration. Therefore, we propose the following: **Proposition T1: The implementation of interoperable technology platforms enhances the communication in collaborative projects.**

3.3.2 Inexperience

The infrastructure industry is not yet utilizing technology enough to reach all the potential benefits. Moreno et al. (2019) discuss that there can be non technical and organizational factors that can be barriers to implementing technologies, such as BIM. Basically this comes down to inexperience and acceptance of technology in the project Becerik-Gerber and Kent, 2010; Moreno et al., 2019; Svalestuen, Knotten and Lædre, 2017). Becerik-Gerber and Kent (2010) explain that there is an absence of a standard BIM contract document and an unclear collaborative framework, this leads to unawareness of how to implement BIM which therefore leads to inexperience within the industry. This also leads to a lack of skills in technology (Becerik-Gerber and Kent, 2010; Moreno et al., 2019; Rahman and Alhassan, 2012) because people do not utilize

it. However, when participants understand the used software, coordination of tasks can be enabled and discrepancies can be reduced with a 3D design program (Kapogiannis and Sherratt, 2018), which leads to a more efficient project. In addition to this inexperience issues, some argue that there is a lack of motivation to utilize technology as well as trust in the systems (Svalestuen et al., 2017). This can be related to the inexperience in the industry, which can be difficult to overcome because implementing technology as well as providing the necessary training to utilize it is expensive and thus the industry is hesitant (Becerik-Gerber and Kent, 2010; Ebrahimi and Dowlatabadi, 2018; Moreno et al., 2019). Also Svalestuen et al. (2017) argues that there is a lack of understanding of the cost/benefit ratio of technology.

To overcome the challenges with personal inexperience, providing training can be a good means to develop skills as well as creating a learning environment, according to Merschbrock and Munkvold (2015). He also suggests that to skill up designers with a technology platform, system developers could be involved for assistance in case of inexperience. Moreno et al. (2019) and Wang et al. (2020) suggest that a BIM-coordinator can also be involved to create understanding and encouragement in the BIM platform among the participants. Ahmed and El-Sayegh (2021) take the training and integration of technology even more serious and argues that the core team should study integration aspects and acquiring training skills together to utilize technology in a project.

Technology is not utilized enough to provides its potential benefits in the infrastructure industry. Our reviewed literature explains that this is an important challenge to overcome so communication and collaboration can be enhanced in a CPDS. The authors suggest different approaches to overcome the inexperience, the two main ideas are providing training and involving skilled technology coordinators (Merschbrock and Munkvold, 2015; Moreno et al., 2019; Wang et al., 2020). Based on this we propose: **Proposition T2: Training within the chosen 3D modelling platforms is the most important factor to utilize the full potential of technology in a CPDS.**

3.4 Summary

In this chapter we have discussed the literature that addresses the challenges related to CPDS. These discussions have lead to a set of theoretical propositions. To sum up the findings from our theoretical work, we expanded the ECT framework by adding the propositions in figure 5, *The ECT framework with propositions*. So far, the framework is solely based on our literature and theoretical work. In order to strengthen the framework we conducted a qualitative case study. In the next chapter 4,*Methodology*, we will give a detailed

description on how we performed this study.

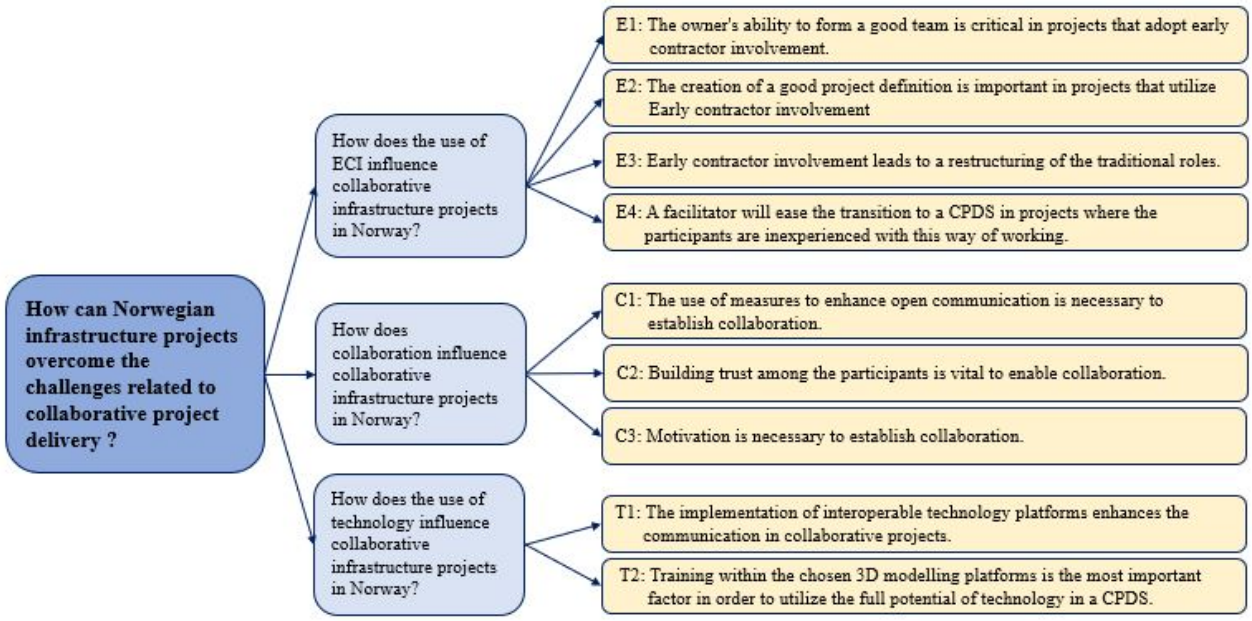


Figure 5: The ECT framework with propositions

4 Methodology

The goal of this research project is to answer our research question, *"How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?"*. The research contains two research parts, a theoretical review and a social study.

In this chapter we are providing a detailed description of how we performed our research. We will also address which measures we took to ensure that our research with holds high quality and high ethical standards. This is done by describing the selected research method, research design, methods for data selection and analysis and research criteria. Furthermore, we will present the ethical considerations we made throughout the work with this thesis. We will end this chapter by presenting our personal reflections.

4.1 Selection of research methodology and design

In this sub chapter, we are describing our process of selecting a research strategy and design. In the sections we are providing our selection and the rationale behind our choices.

4.1.1 Research Strategy

In social research mainly two methods are utilized, the quantitative method and the qualitative method (Bryman, 2016). The quantitative method adapts a deductive perspective, which means that it aims to test existing theory based on gathered data. It provides explanations based on numbers and relies generally on large sample sizes (Bryman, 2016). On the other hand, the qualitative method adapts a broad perspective and utilizes the data to generate new theory, thus it has an inductive perspective (Dalland, 2012; Bryman, 2016). It emphasizes on discovering issues that are hard to describe via numbers, like meanings and experiences (Dalland, 2012). He also argues that the qualitative method aims to go in depth on a phenomenon and to provide the reader with understanding. Similarly, Creswell (2014) state that "Qualitative research is an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem" (p.4).

Our research question, *"How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?"*, aims towards creating a deeper understanding of the challenges related to CPDSs in Norway. Thus, it seeks to discover the meanings and experiences of the practitioners in the Norwegian AEC industry. According to the statements of Dalland (2012) and Creswell (2014), the qualitative

method is perceived to be the best fit for this purpose. Furthermore, we asses that it is hard to answer the research question based on numbers and measurements. Lastly, we have limited access to the AEC industry, thus we will not be able to create a large enough sample size to conduct a reliable quantitative research. Based on these factors, we are choosing to pursue a qualitative approach to our research study.

4.1.2 Research Design

According to Bryman (2016), a research design "refers to a framework or structure within which the collection and analysis of data takes place" (p.695). He also states that the most common designs are: experimental, cross-sectional, longitudinal, case study, and comparative. We exclude the experimental design, because we are not able to control the environment nor manipulate the different variables affecting it. The longitudinal design is also excluded, because the time frame needed to perform such study exceeds the time frame available for this thesis. The goal of the cross-sectional design is to collect data on several cases in order to search for patterns of association between variables (Bryman, 2016). Hence, we assess that the cross-sectional design does not fit our research question. That leaves the alternatives, comparative and case study. Both designs focus on studying cases. Yet, there are some differences. The traditional case study emphasizes on a single case, while a comparative design studies multiple cases and compares them. Yin (2018) states that case studies are well fitted to examine *why* and *how* based research questions. Furthermore, Dubois and Gadde (2002) state that "Case studies provide unique means of developing theory by utilizing in-depth insights of empirical phenomena and their contexts" (p.556). From this we derive that conducting a case study will give us an opportunity to better understand the issues related to collaborative project delivery within our context, *Norwegian infrastructure projects*, and is best fitted for our research. Hence, we will pursue a case study.

4.2 Designing the Case Study

In this sub chapter, we are providing our considerations and rational behind our approach to our research. According to Yin (2018), careful consideration of the research question, propositions, and the units of analysis is important when designing a case study. Therefore, we are addressing these elements as well as our approach to the literature review, interview guide, data collection, data analysis, and result sharing.

4.2.1 Developing the research question

A research question is a question that is asked with a specific goal. It should be asked in such a manner that it is possible to study by research methods. Furthermore, it should be relevant for the field of study, and it

should contribute to delimit the scope of study (Dalland, 2012).

Our initial plan was to continue on our project thesis (see Buijing and Hellebust (2020)) and study the application of IPD in Norwegian infrastructure projects. However, after some research we realized that there is only one project that implemented IPD and we did not have access to this project. In cooperation with our case company, we had access to projects that utilize ECI, Collaboration and Technology. These elements are important in a full-fledged CPDS and in a Hybrid, thus in general for a collaborative project (see sub ch. 2.4). Taken this in consideration as well as the fact that we did not have access to the contract of our case projects, we changed our research focus to CPDS. Consequently, we formulated a new research question for this thesis to do research on CPDS in Norway.

> *How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?*

This research question describes the scope of the study and in which context it will be conducted. Thus, it acts as a guideline throughout the study. However, the scope is still quite broad. Therefore, we narrowed it down by creating of a set of sub research questions and propositions. This process will be addressed in the next section.

4.2.2 Developing the Sub Research Questions

Part of our literature review was examining the explanation of the existing literature of collaborative project delivery systems. By reviewing various articles on TPDS, IPD, Alliancing and hybrids we could create a general definition for a CPDS (see chapter 2). This definition has enabled us to perform our research on the new developed CPDSs in Norway as well as it provides a general definition on a CPDS for further research. This definition created a natural limitation for our research focus which is the challenges related to ECI, Collaboration, and Technology. Consequently, we created the following sub research questions:

- *How does the use of ECI influence collaborative infrastructure projects in Norway?*
- *How does collaboration influence collaborative infrastructure projects in Norway?*
- *How does the use of technology influence collaborative infrastructure projects in Norway?*

With these focus areas for the challenges related to CPDS, we could perform a more specific literature review. We will provide our considerations with this review in the next section.

4.2.3 Literature Review

There are many reasons for conducting a literature review. It can give an overview of a new field, it can reveal research gaps, it can give ideas or it can enable the researcher to place the research in a larger context (Knopf, 2006). According to Bryman (2016) there are two types of literature reviews, the systematic and the narrative. The systematic review is rigid in its nature and adopts specific procedures and emphasizes on being replicable. The narrative review is less rigid and tends to have a wider scope than the systematic review. Thus, it allows the researcher to follow trails of interest that appear in the research. It also allows for revers snowballing, which means that the researcher uses the literature list of interesting articles actively in the literature search. Thus, the narrative literature review presents a good strategy for researchers that are reading into a new field of study.

Our literature review builds on the literature review that we conducted in our project thesis, Buijing and Hellebust (2020). This review was a narrative review aiming to uncover the challenges related to IPD. Even though our research question, *"How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?"* does not address IPD directly, many of the perspectives are still interesting in this thesis, as IPD is a CPDS as explained in sub chapter 2.3, *Collaborative project delivery*. Nevertheless, we extended the literature review and put more emphasis on the three areas of interest, early contractor involvement, collaboration, and technology.

The literature review has been executed by using search engines such as Oria and Google Scholar. We used the search words challenges, barrier, infrastructure projects and collaborative project delivery together with ECI, collaboration or technology. By considering the number of citations, year of publication, journal publication and considering overlap of the articles in our search we narrowed down the list of appeared articles. As well as references within the articles, thus the snowballing method, has been used to find relevant articles. To organize all the chosen articles and challenges, we created a table that shows the authors with their stated challenge in the related area of interest (see appendix A). The literature review has enabled us to suggest propositions that lay a theoretical foundation for answering the sub research question. After conducting the literature review we set out to conduct the case study. The first step of designing this study was to select the units of analysis which we address in the next section.

4.2.4 Units of Analysis and Sampling

The purpose of selecting the units of analysis is defining and bounding the case (Yin, 2018). In order to answer our research question, we decided that our unit of analysis should be the projects. We used purposive sampling when deciding which projects to include. Purposive sampling means that the research participants are sampled in a strategic way, so that the samples are relevant to the research question (Bryman, 2016). In cooperation with our contact in the case company, we selected two infrastructure projects within their project portfolio. Due to choice of case study as research design (see section 4.1.2) we had to find projects that would be similar to be able to treat them as our studied case which is collaborative infrastructure projects in Norway. The projects that we selected are similar and are both characterized as innovative in a Norwegian context. The latter because they are amongst the first collaborative infrastructure projects in Norway. The examination of those two projects allowed us to look for common challenges in the projects and exclude alternative explanations (Yin, 2018). Yin (2018) states that this approach tends to create more robust theory.

We also used purposive sampling in the process of selecting informants. We identified a set of criteria for suitable informants to interview. Our criteria were that the informants should represent the different actors in the projects and that there should be variance in their level of experience and their position within the projects. The sampling based on these criteria was done by a contact person in each project. One can criticize this approach because as a researcher you lose control over the sampling. However, we chose this approach conscious, because the contact persons have a better insight in the project and its participants. Hence, they can better evaluate which people fitted our criteria than us.

4.2.5 Developing the Interview Guide

Bryman (2016) states that there are three strategies to conduct an interview. Structured, unstructured and semi-structured. In a structured interview, the researcher aims to standardize the interview and the questions are typically rigid and closed. An unstructured interview has very few guidelines and emphasizes on letting the interviewee respond freely. The semi-structured interview is more rigid than the unstructured and the researcher has typically prepared an interview guide that describes the topics that are to be discussed. However, it still allows the interviewee to respond freely as well as it allows the researcher to follow trails of interest (Bryman, 2016). We chose to use the semi-structured approach, because this allowed us to steer the interviews towards our point of interest and, at the same time, gave us the possibility to follow trails of interest that appeared during the interviews. Furthermore, we have no experience with conducting an

interview and perceived that we increased our chances for conducting a good interview when having an interview guide to follow.

We developed our interview guide with the aid of our supervisor and our contact person in the case company. They gave us insights in, respectively, academical research and the industry. We used these insights to develop an interview guide with well-formulated and understandable open-ended questions which were focused on our field of interest. However, after conducting the first two interviews, we noticed that answers to some questions coincided and we merged these questions in further interviews. Our interview guide can be seen in appendix B, *Interview guide*. In the next section, we are describing how we conducted the interviews in order to collect data.

4.2.6 Data Collection

In total we conducted nine semi-structured interviews with ten informants in our sample. The interviews were conducted via Microsoft's Teams as it proved to be hard to plan and conduct in person interviews due to the geographical distance and the COVID-19 pandemic. Conducting the interviews via Teams had some practical benefits, such as eliminating the need for traveling and reducing the time consumption of the interviews. It also allowed us to keep our schedule, in a time where all physical meetings had a high risk of being postponed or cancelled due to COVID-19.

However, we encountered some difficulties because we were not able to influence the informant's surroundings. We experienced that some of the informants got distracted during the interviews, either by the phone or by other people. Bryman (2016) warns for such situations and states that to avoid interruptions, the interviewer should choose to perform the interview in a quiet location free of distractions. Even though we were not able to ensure this, the occurred distractions did not influence the interview noticeably, except for one interview, wherein the informant got an urgent call and was clearly distracted for the last fifteen minutes of the interview.

In preparation of the interviews we sent the informants an overview of which topics the interview would cover as well as we asked them to perform the interviews in English as one of the researchers is a non-Norwegian speaker. However, to lower the level of discomfort for the informants, we emphasized that they could switch language for parts of the interview if necessary. Which mainly was applied on certain terms during the interviews. We conducted one interview in Norwegian due to the informant's comfortable level

in English. We noticed that this was the hardest interview to conduct. One reason for this was that one of the researchers became passivated due to language issues. However, the major issue was that the informant tended to stray away from the topic of the question and started to explain technical details. We noticed that this was not the case in the other interviews which was probably due to the interviews being conducted in a foreign language. One might argue that the language influenced the informants ability to give complementary answers. However, we perceived that the given answers were detailed enough for our research.

The duration of the interviews were approximately one hour. In most interviews we managed to go through the whole interview guide as well as to follow trails of interest. However, we did not follow the interviews guide slavishly, but rather jumped back and forth between the topics to not interrupt the flow of the conversation. This is one of the benefits of a semi-structured interview, mentioned by Bryman (2016) (see section 4.2.5). In one of the early interviews, we followed to many trails of interest and ran out of time before we had covered the whole interview guide. However, this interview provided us with rich descriptions of the topics we did cover. Table 3, *Features of the conducted interview*, shows an overview of the features of each interview that we conducted.

No. of people	Interview lenght	Role	Company	Project	Experience
1	59 min	PM Design	Design Firm	A	10 years
1	46 min	PM	Owner	A	30 years
1	55 min	PM	Contractor	A	25 years
1	50 min	BIM	Contractor and Design Firm	A	15 years
1	51 min	DM	Contractor	A	19 years
1	45 min	BIM	Designer	B	8 years
1	61 min	PM	Subcontractor	B	17 years
2	51 min	DM BIM	Contractor Contractor	B B	4 years 8 years
1	52 min	PM	Owner	B	16 years

Table 3: Features of the conducted interview

We audio recorded the informants during the interview, so that we could focus on conducting a good interview rather than focusing on taking notes. Nevertheless, we did take some notes in order to structure or to follow up question as well as to note when the informants showed emotions through facial expressions or tone. After the interviews, we transcribed the audio files to enable coding and analysis of the data. In the next section, we are describing how we coded the data.

4.2.7 Coding

The analysis is about finding information in the data that is collected through the interviews. It is, therefore, important to present the content in a factual way (Kvale and Brinkmann, 2015). To analyse our data accordingly, our first step was to transcribe our audio files. The benefits of the transcription were that we could focus on details, that it was easier to find interesting opinions in our written files, and that we could recognize intriguing quotes. After transcribing, the next logical step was coding the data (Bryman, 2016). We used axial coding, which is an inductive method that allows the researchers to view the data in new ways by creating connections between categories (Bryman, 2016). More specific, we used the coding method that is described by Gioia, Corley and Hamilton (2013). The method entails to categorize the different quotes and perspectives into a set of categories, the first order concepts. After that the researcher looks for similarities and differences amongst these concepts, in order to uncover a deeper structure in the array of the first order concepts. Hence, creating a set of second order concepts. Finally, the second order concepts are distilled into a set of aggregate dimensions (Gioia et al., 2013). After creating a manageable set of first order concept we categorized these into twelve second order concepts. Next we used these to create five aggregate dimensions. The aggregate dimensions form the structure of chapter 5, *Empirical Findings*. The coding made it easier for us to analyse and compare the data from the different interviews. It also provided a structured way of transforming the raw data to terms and concepts (Gioia et al., 2013). An example of our coding structure is included in figure 6, *Example of coding structure*, to visualize our coding process. The full coding structure is very extensive and covers approximately fifteen pages. Therefore, we chose to add only an example in the thesis. In the next section, we are describing how we used the analysis to create theory.

4.2.8 Creating Theory

As mentioned in the previous section, we utilized the Gioia method when coding the data, which is an inductive approach (Gioia et al., 2013), this allowed us to stay close to the data throughout the coding process. However, when examining the theoretical implications of our data, we adapted a more abductive approach. Our process is coherent with systematic combining (Dubois and Gadde, 2002). According to Dubois and Gadde (2002), in systematic combining the different steps of the research are addressed iteratively and the theoretical framework can be redirected as the case appears. Throughout the process from the literature review to the conclusion, we worked with the ECT framework, by complementing and revising it in order to reflect our findings. The framework first materialized when we were working with the analysis in chapter

6, *Analysis*. However, we quickly identified that the framework was built on the findings from the previous chapters. Thus, we chose to structure our thesis by using the ECT framework. In order to identify the theoretical implications of the framework, we first evaluated and revised our theoretical propositions based on our empirical data (see ch. 6, *Analysis*). Next, we discussed the different perspectives in the existing theory in light of our analysis (see ch. 7,*Discussion*). This was done in order to evaluate the theoretical implications of our findings.

In the next sub chapter, we are addressing and evaluating how we worked to ensure the quality of our research project.

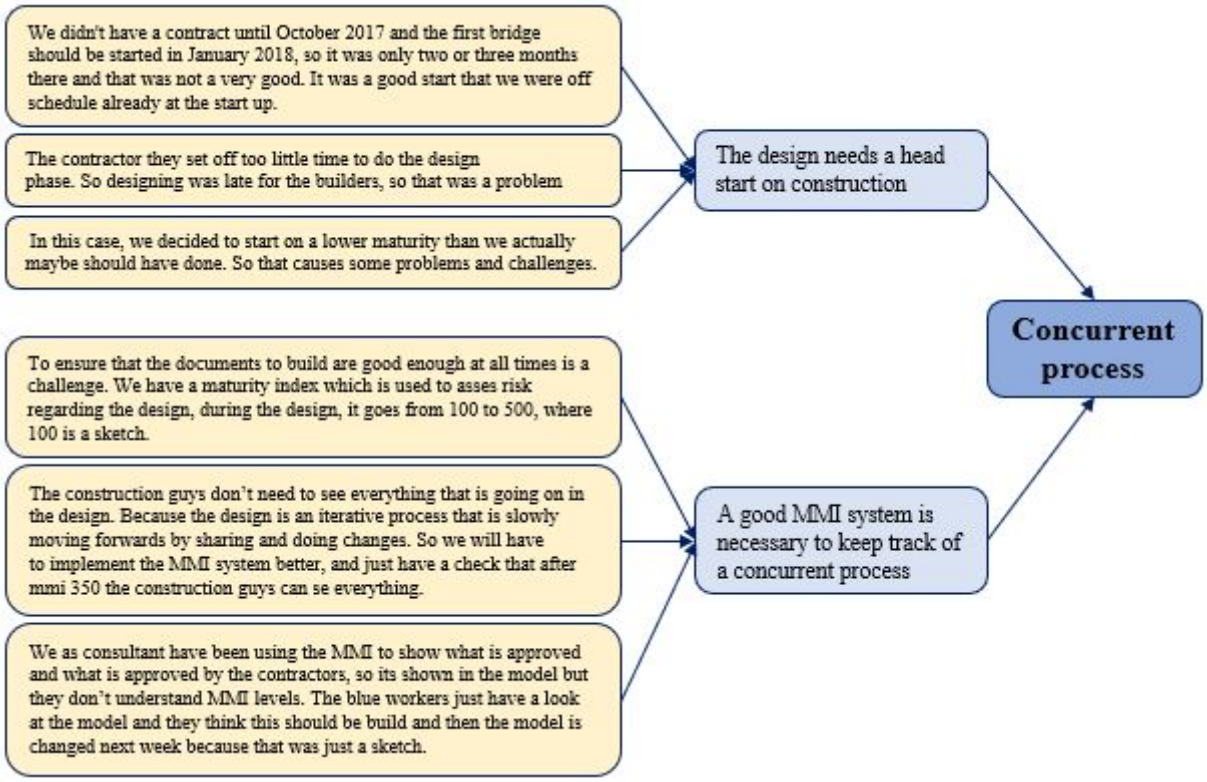


Figure 6: Example of coding structure

4.3 Research Criteria

It is common to evaluate social research based on a set of criteria. The most common criteria is validity and reliability Bryman (2016). However, Guba and Lincoln (1994) argue that these presuppose that there exist an absolute account of social reliability, which might not be the case. They propose two alternative criteria, trustworthiness and authenticity. There is no final agreement to what criteria is best suited to evaluate

qualitative research and there are even other alternatives. Nevertheless, (Anney, 2014) recommends the trustworthiness criteria because it will increase the believability of qualitative research. We follow this recommendation and are evaluating our thesis by trustworthiness and authenticity in this sub chapter.

4.3.1 Trustworthiness

Trustworthiness refers to whether good research practises are followed, whether the researches has understood the social world that is studied correctly, whether the contextual context is described so it can be evaluated on relevance for other settings, and lastly, if the research is influenced by personal values or theoretical inclination. Trustworthiness consist of four criteria credibility, transferability, dependability and confirmability (Bryman, 2016; Guba, 1981). In this section we are describing these four criteria and we are explaining how we addressed them when conducting our research.

Credibility

"Credibility is defined as the confidence that can be placed in the truth of the research findings" (Anney, 2014, p.272). However, Bitsch (2005) argues that truth is not provable, thus in a qualitative research correspondence with reality is replaced with correspondence of the participants perspectives. This indicates that there exists several perspectives and that in order to uncover the truth, one must take all of these perspectives into account. To uncover the different perspectives and to avoid bias, we selected informants from different companies and hierarchical levels (see section 4.2.4). This gave us different perspectives on the topics as well as the possibility to compare the answers.

Transferability

Transferability refers to what degree the research can be generalized and transferred to other contexts (Anney, 2014; Bitsch, 2005). In order for the reader to judge if the findings of the research are applicable in other contexts, qualitative researchers are advised to provide a thick description of the context (Bryman, 2016; Bitsch, 2005). Bitsch (2005) also argue that the sampling might affect the transferability. To provide the reader with sufficient data to determine whether our findings are transferable to other contexts, we provided a thorough description of the selected cases (see section 5.1), and we elaborated the choices made in relation to our sampling (see section 4.2.4). In addition to this, we chose to exclude issues related to contracts, as these issues are heavily influenced by national laws and regulations and thus likely context specific.

Dependability

Dependability refers to "the stability of findings over time" (Bitsch, 2005, p.86). Thus, dependability addresses whether the results would be the same if the research was replicated. Dependability is typically achieved by keeping an audit trail (Bryman, 2016), or "a detailed and comprehensive documentation of the research process and every methodological decision" (Bitsch, 2005, p.86). To ensure the dependability of our thesis, we described our research process in detail in chapter 4, *Methodology*. As well as we addressed the choices we made in relation to the creation of research question, sampling, data , etc. Additionally, we have included a copy of our interview guide in the appendix (see appendix B) and an example on how we analyzed the empirical data (see section 4.2.7).

Confirmability

According to Bryman (2016), it is not possible to achieve complete objectivity in qualitative research. Thus, the criteria of confirmability is introduced in its place. Confirmability addresses whether it is visible that the researcher has acted in good faith and avoided personal values or theoretical inclination to influence the results (Bryman, 2016). To increase the level of objectivity and avoid bias by our own inclination, we carefully developed and considered our interview guide to ensure it did not induce our meanings or inclinations on the informants. In addition, we asked two externals to review the interview guide. We also worked systematically when analyzing our data to stay true to the empirical data by the use of the Gioia et al. (2013) method (see section 4.2.7).

Throughout this section we addressed the efforts we made to establish trustworthiness. We asses that the measures that we put in place are sufficient to show that we acted in good faith and tried to avoid the results to be affected by our personal inclination. We also asses that the description of our research process and context is sufficient for others to replicate the study and to evaluate whether our findings are transferable to other settings. Thus, we assess that our thesis withholds high standard with regards to trustworthiness. In the next section, we are addressing the authenticity criteria.

4.3.2 Authenticity

Authenticity is a set of criteria that addresses issues concerning the broader political impact of the research (Bryman, 2016). Unlike most other criteria, authenticity emphasizes that research should have a practical outcome, making it relevant in fields like organizational and educational studies (Bryman, 2016), such as our

study. The criteria that sorts under authenticity are: fairness, ontological-, educative-, catalytic- and tactical authenticity (Lincoln and Guba, 2013)). Fairness is mainly concerned with how the researcher represents the studied world, while the four other criteria are mainly concerned with the practical outcome of the research. Therefore, we address these as one entity in this section.

Fairness

Fairness addresses whether different viewpoints amongst the members of the social setting is represented in a fair manner (Bryman, 2016). To ensure fairness, one must ensure that all meanings have been accessed, exposed, deconstructed and taken into consideration in the final product (Lincoln and Guba, 2013). One might argue that a very large sample size is required in order to achieve this. However, the participant's time is a scars resource. Thus, we were not able to have a large sample size. To ensure fairness despite the restrictions in sample size, we thoroughly evaluated the selection of the interview objects. In order to uncover the different perspectives we interviewed people with different roles and positions (see section 4.2.4).

Authenticity

An important part of the authenticity relates to the practical implications of the study. It is concerned with whether the research helps the members of the social context in question achieve a better understanding of their social environment and the perspectives of others. It also concerns whether the research has empowered or motivated the members to engage in actions to change their environment (Bryman, 2016). Our research project aims to uncover challenges related to Collaborative Project Delivery in the Norwegian infrastructure industry. The thesis in itself proposes new theory in the field that might help the practitioners in the industry to better understand the challenges they might face when executing collaborative infrastructure projects. Furthermore, as mentioned under fairness, we sought to examine the topic from different angles. Thus, contributing to a better understanding of the environment and the different perspectives that exist within it. This thesis also suggests measures to avoid some of these challenges. It is not very likely that this thesis will lead to a major change within Norwegian infrastructure projects or that it empowers the participants to engage in change. However, we think that the ECT framework that is introduced in this thesis can give valuable insights and guidance when analyzing collaborative infrastructure projects in Norway. Furthermore, we have included some practical advice on how to overcome the challenges of such projects (see sub ch. 8.3). These advice comprise the practical implications of our findings. By providing new insights and giving advice, we hope to inspire and empower the practitioners of Norwegian infrastructure projects to improve the way they

organize projects and in so to increase the authenticity of this thesis.

In this sub chapter, we have explained how we acted to establish trustworthiness and authenticity in our research. In the next sub chapter, we are addressing how we proceeded to maintain a high ethical standard throughout the whole research project.

4.4 Ethical Considerations

To ensure that our research project and this thesis keeps a high ethical standard, we emphasized several ethical considerations during our work. Ethical considerations in social research can take many forms and many names, however they tend to revolve around the same issues (Bryman, 2016). As described in Bryman (2016), Diener and Crandall (1978) have broken them down to four main issues:

1. whether there is harm to participants
2. whether there is a lack of informed consent
3. whether there is an invasion of privacy
4. whether deception is involved

In this sub chapter, we are describing how we strived to ensure a high ethical standard, based on the mentioned issues. However, the research process also needs to comply with the local rules and regulations (Bryman, 2016). Thus, we are starting the chapter by explaining how we addressed this issue.

4.4.1 Local Rules and Regulations

In Norway, research projects that treat information that can identify individuals must be approved by the Norwegian Centre for Research Data (NSD) (Dalland, 2012). To get approval from NSD, an application where one must describe information regarding how and which data will be collected, how the data is handled and stored, and which measures that are taken to protect the anonymity of the participants. In addition, a copy of the interview guide and the info letter must be attached in order for NSD to control that the research does not expose vulnerable groups or easily identifiable people. A copy of our approval is attached in appendix C, *NSD approval*. To ensure that we did not violate the NSDs regulations, we waited until we received the approval before we started our data collection. The approval also verified our perception of which information is legally and ethically accepted to collect. NSD used 30 days to process our application, so we were not able to plan and conduct the interviews as early as we would have liked to.

However, we started the application process quite early and the time concern was easily outweighed by the benefit of ensuring compliance with the local rules and regulations.

4.4.2 Harm to Participants

Bryman (2016) states that harm to the participants can take many forms; physical harm, loss of self esteem, stress, etc. Furthermore, he argues that influencing people to do or say things that may create negative consequences for them, is also a way of inducing harm. We asses that there is a very small chance that our research will do any harm to the participants, as our interviews were mainly concerned with organisational challenges in the projects where the interviewees work. Kvale and Brinkmann (2015) state that there exist a power relation during the interview that is in the informants disfavour, this may induce stress for the informant. To allow the informants to prepare for the interviews and in so reducing the amount of stress during the interview, we sent an overview of the topics that would be addressed in the interview. Furthermore, we ensured that the informants were comfortable with performing the interviews in English and offered to perform them in Norwegian if they felt uncomfortable with this (see section 4.2.6). We think these measures were especially important because the interviews were conducted digitally which made it harder to connect with the informants. Optimally, we would have liked to conduct the interviews in person, as this would allow us to better interpret body language and face expression, and thereby made it easier to adapt to the mood and setting. However, this was not possible because of the COVID-19 pandemic. Based on the described measures and the fact that our unit of analysis is the projects and not the individuals, we are confident that there will be no harm to the participants in our research project.

4.4.3 Informed Consent

Yin (2018) states that researchers should gain informed consent from everyone participating in the study. This should be done through informing them of the nature of the study, including the effort they need to make and formally ask for their voluntary participation Bryman (2016); Dalland (2012); Yin (2018). However, it is extremely difficult to provide the participants with all the necessary information for them to make an informed decision to participate (Bryman, 2016). We ensured informed consent by asking the participants to sign a form of consent (see appendix D). In this form we informed the participants about the topic and goals of the study, the length and character of the interview, how their data would be treated, that their consent could be retracted at any time, and how they could get insights in their data. In addition, we repeated the most relevant issues at the start of every interview. Based on these measures, we assess that we have received informed consent from all informants.

4.4.4 Invasion of Privacy

According to Bryman (2016), a researcher should be careful not to invade the privacy of the informants. Furthermore, he states that privacy often is linked to anonymity and confidentiality. However, the questions being asked in the interview can also be perceived as invasive by the informants and as a result they may refuse to answer (Bryman, 2016). Dalland (2012) argues that the nature of the research also influences how sensitive the researcher should be. Interviewing people about private experiences have a larger potential of being perceived as invasive than when professionals are being interviewed regarding their profession. Our study is of the latter character. Thus, it is not likely that we experienced issues related to invasion of privacy. Nevertheless, to ensure that our questions were not invasive and thus to protect the informant's privacy, we have reviewed our interview guide several times and made sure that the questions were relevant for our work and only examined the informant's professional work. Nonetheless, we had to conduct the interviews online due to the COVID-19 pandemic. This also meant that most informants were restricted to home office. Many informants used a filter as background to protect their own privacy. Our contribution to not invade the privacy of their homes was to only use audio recording instead of video recording.

4.4.5 Deception

Some researchers use deception in order to get people to respond more naturally to experiments (Bryman, 2016). However, researchers should avoid deception because, as Bryman (2016) puts it, it is "not a nice thing to do" (p.133). Involving deception in the research also contradicts the principle of informed consent. To avoid deception, we have been forward with the informants and the involved companies regarding the goals and implications of our projects. However, the nature of a qualitative research emphasizes to allow the researchers to follow trails of interest Bryman (2016). These trails are hard to predict and thus the researcher is not able to inform the involved parties regarding themes that emerge during the process. We strived to be open and straight forward regarding the evolution of our research process, and had no intention of deceptiveness.

In this sub chapter we described how we worked and which measures we used to ensure a high ethical standard in our research. The topic of our research is not very sensitive. We made efforts to ensure that the informants knew the effort required from them and how we were treating the collected data. In addition, we emphasized being open about the goals and implications of our study in order to avoid that the participants felt deceived. Based on this we asses that our research projects withholds a high ethical standard. In the

next sub chapter, we will present our personal reflections on the research process.

4.5 Personal Reflections

Prior to this thesis, we had no experience or ”know how” on how to conduct a large social research project. Our lack of experience might have led to some nontraditional choices and sub-optimal solutions. In order to counter this, we started early and intensively on gaining the knowledge on how to perform such research. We did this by the means of literature and our supervisor, who has been a very helpful resource. We slowly managed to grasp the work that had to be done. In the beginning it has been a steep learning curve to understand the principle of social research. In the middle, when we were collecting data, it was a matter of waiting to the point we gathered all the data. After that, it has been another steep learning curve, since we started to see what we could contribute to the literature by doing this empirical research as well as all the pieces started to fit together. When we started to edit the first draft, we could clearly see that there had been an evolution in how we wrote and thought. When starting this thesis, we were used to use theory to address real life situations. Thus, treating the theory as an established truth. Throughout the work with this thesis, we learned how to critically evaluate and discuss the theory based on empirical evidence. This improved our ability of critical thinking and improved the way we handle theory.

This master thesis is a continuation of our project thesis on IPD. We experienced difficulties related to the topic when transitioning from the project thesis to the master thesis. We wanted to do research on IPD in the Norwegian context, however our case company is not involved in any of the very few IPD projects executed in Norway. They did use IPD elements in their projects which made their projects still relevant for us. However, we found it difficult to find the right approach to do a study wit these projects as case. After four weeks of discussion and an intensive literature review, we found a good approach. We decided to create a thorough description of the different systems and then formulate a broad definition based on a comparison of these systems (see ch. 2). This definition enabled us to do our research with the available projects and it created a foundation for the ECT framework. Thus, in our opinion the ECT framework is valuable tool when looking into collaborative project delivery, as it allows researchers to apply theory from several collaborative traditions.

Our collaboration for our thesis started late, because we started out writing separate project theses. However, both of us missed having someone to discuss with and we decided to start working together in the end of October. As a result we had to write the entire project thesis in just two months. However, we quickly

learned how to collaborate and work efficiently together, which mainly came down to planning and communicating together. This has been a success factor that we decided to also implement in our master thesis. The project thesis was performed in a hectic two months. However, we are sure that decision of working together payed off, as we think that our discussions have improved the quality of both the project thesis and this master thesis.

We have used the knowledge gained during our master in Project Management when starting this master thesis in order to avoid the hectic situation we experienced when writing the project thesis. We are sure that our approach to this master thesis has benefited from our educational background as we planned it as a project. We started working actively from the beginning of January and we emphasized creating a resilient plan. We identified critical tasks and risks, and allocated extra time where we found the risk for delays to be high. There has been some delays, especially in relation to conducting the interviews. We experienced that the informants were very busy and at times hard to reach. In addition, one of our contacts left the company, and thus left the case project. However, we had identified the interview process as a critical process. Hence, we had allocated extra time and moved the interview process forward in the project timeline. As a result, we managed to overcome these setbacks with ease. In addition to our sufficient planning, we found that communication was the key to collaborate effectively and thus we scheduled a meeting every day to discuss the thesis. This gave us opportunities to discuss each others work, the process of each other as well as we kept each other updated on expectations of the thesis. We also discussed each others strengths in order to gain the benefits of division of the work. For example, one of us is very good in finding relevant information in articles and making up a first draft, where the other one has an eye for detail and could condense and correct the first draft. We perceived our collaboration, planning and shared motivation for creating a good product as a success factor of our thesis process.

We performed our research during the on-going COVID-19 pandemic. This lead to a situation where we were located in different locations and thus had to collaborate via online platforms during the entire thesis. This also applied to the interviews which needed to be conducted online. We were prepared this and thus discussed how to handle this situation. By discussing expectations and problems together, we did not find difficulty in collaborating online. When conducting interviews online, we were unable to ensure that the informants were only focused on the interview. In some of the interview this lead to interruption like phone calls or family members interrupting. But for most of the time the informants gave us their full attention. It also proved to be easier to get hold of good informants when conducting the interviews online as it is less

time consuming. All in all, we think that we handled the challenges related to the pandemic in a good way.

To sum up, there has been some challenges related to collaboration, getting hold of informants and COVID-19. However, due to good and early planning we have managed to overcome them and are proud of our final product.

5 Empirical Findings

In order to enable a discussion that provides an answer to our research question, *"How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?"*, we are presenting the findings from our empirical study in this chapter. As mentioned in section 4.2.6, *Data Collection*, the data originates from nine interviews with ten individuals. The chapter starts by describing the two case projects. Next, we are presenting our empirical findings. During the coding of the material, we categorized the findings into five categories. The categories are Traditional vs Collaborative PDS, Early Contractor Involvement, Collaboration, Technology and Concurrent process. These categories are forming the structure of this chapter.

5.1 Case description

In this research project, two large public road projects in Norway were selected for data collection, henceforth referred to as Project A and Project B, in order to keep the informants anonymous. The projects are conducted by the same public owner and they are conducted as contractor managed DB. Thus, the contractor is responsible for conducting the project from start to end. To achieve this, the contractors have cooperated with external design teams. Both projects used Best Value Procurement (BVP) in the tender phase. The projects are quite similar with a few differences. We will provide a brief description of the two case projects in the next sections, after we evaluate whether the differences will have an impact on how to process our data.

5.1.1 Project A

Project A has a contract value of approximately 2.3 billion NoK. The DB entity was lead by a contractor that hired one external design firm. During the early phases and the design phase the participants from the core group, the owner, the contractor and the designer, were co-located in the contractors facility. The owner demanded high standards with regards to the use of new technology, such as BIM, they also included a reward for achieving these standards. The DB entity was involved in the project from the end of the zoning phase. In addition, the contractor is responsible for 30 year of maintenance.

5.1.2 Project B

Project B has a contract value of approximately 1.7 billion NoK. The DB entity was also lead by a contractor that hired two external design firms. They also hired a subcontractor to perform the electrical design

and construction. The owner demanded that the contractor created a BIM model that was handed over at the closeout. In the early phases of project, the team was co-located. When the contractor moved to the construction site, some of the core participants followed to continue the co-location. However, in the end of the phase the co-location stopped. The DB entity was involved in the project from the start of the zoning phase. In this project the contractor is responsible for 20 years of maintenance.

5.1.3 Overview of project characteristics

An overview of the characteristics of the two case projects are presented in table 4, *Characteristics of the case projects*. As one can derive from the project descriptions and the table, the projects have very similar characteristics with some minor differences. We assess these differences are so small that it allows us to treat the two projects as samples in a single case. This allows us to look for common challenges and exclude alternative explanations. Thus, creating more robust theory (Yin, 2018) (see ch. 4.2.4).

	Project North	**Project South**
Time of involvement of contractor	End of zoning	Start of zoning
The contract value	2.3 Bn NoK	1.75 Bn NoK
The maintenance period	30 years	20 years
No. of involved design firms	1	2
No. of involved subcontractors in the core group	0	1
3D modeling and desing	Yes	Yes
Period of being co-located	During the design phase	During the design phase

Table 4: Characteristics of the case projects

In this sub chapter, we described some characteristics and context for the two case projects that we used in our study. This gives a better understanding of the empirical findings that we are presenting in the following sub chapters.

5.2 Traditional vs Collaborative projects

Our interviews were conducted to investigate the challenges of a CPDS and how to overcome these challenges. However, we also asked the informants for their view of a traditional projects and a collaborative project. Thus, their understanding of the differences between a TPDS and a CPDS. In this sub chapter,

we are providing the differences that our informants described, which are contract type, the timing of the involvement of participants and the consequences of this, as well as the use of technology.

The owner of project A explains that the projects were a lot smaller and consisted of multiple contracts that were conducted after each other in a TPDS. When they utilize a CPDS it is often one big contract which can have three times the value of a traditional project. All informants mention that a traditional projects utilizes a DBB contract. The designers and contractors explain that this means that the owner hires a designer, who will design the project in detail. After other stakeholders agree with the plan, it will be put up for a tender. Contractors can bid on this tender and get a unit price contract with the owner. One of the designers in Project B explains that in such systems the contractor with the lowest price will win the tender. The informants tell that one of the major differences is that collaborative projects use ”contractor managed DB”.

All informants also describe that there is a difference in the involvement of the participants. They say that in a traditional project the contractor is involved after the design is finished, while in a collaborative project the contractor is involved from the start of the project. One of the contractors explains that in a traditional project the owner has more risk, because they have to make sure that the design firm does its work well. This risk is transferred to the contractor in a collaborative project, as well as the control of all the parts of the subjects in the project, such as building, planning, and managing of stakeholders, according to the contractors. The owner of project A explains that in a collaborative project there is more collaboration between the contractor and the designer, but also between the contractor and other stakeholders, this collaboration was less in a traditional project, because the owner would manage each individual. A designer in project A explains that collaboration of a traditional project was just a follow up, through weekly, physical meetings, which he says is more a status update between participants than collaboration. However, the subcontractor in project B has a different perspective on the collaboration of certain participants in a collaborative project:

> *”Normally, the electrical consultants are in the same company as the other disciplines. I think this makes collaboration easier. As of now, they are standing a bit on the outside.”* PM, Subcontractor, Project B

The last difference that is mentioned by the informants is the use of technology in the collaborative projects. A design manager talks about the change of all the drawings being paper based to being model based. He says it is revolutionary to only use models, BIM models, throughout the entire project. Other informants

are also mentioning that digital platforms, such as VDC, BIM and other collaborative platforms which are utilized in collaborative projects, but not in traditional projects. However, one of the designers mentions that in traditional projects they did use technology, but no collaborative platforms.

> *"The design was paper based, drawings, in the start. Now, it is totally integrated in BIM. (...) [Project A] is in lead of using BIM."* PM, Owner, Project A

5.3 Early Contractor Involvement

One of the major differences between the case projects and a traditional infrastructure project is that the contractor is involved in the project from the early phases (see ch. 5.2). In this sub chapter, we are examining how the informants are perceiving the challenges related to the early involvement of the contractor. We are dividing this sub chapter in three sections with a focus on change of roles, a competent contractor and room to find good solutions.

5.3.1 Contractor takes a managing role

All informants mention that the collaborative approach, that is applied in the case projects, is a new way of working for them. Nevertheless, they all see this as a positive change and explain that these projects are a learning process for future projects. They explain that they are willing to learn how to work in these kind of projects. The designers, contractors and owners tell that there is a need to change the traditional roles in order to cope with this new way of organizing. The informants of both projects say that their project is organized as a contractor managed DB. They are explaining that this leads to a tighter connection between the contractor and the designers. There is also an agreement that this way of working is relatively new, as the designers have been working closer to the owner than to the contractor in traditional projects. One of the informants argues that the use of a facilitator could be used to ease this process. He also tells that he has acted as a facilitator several times and emphasizes that the facilitator should be an external part which has extensive experience from working for both owners, the contractors, and the designer.

> *"In a unit price contract, the client and the design firm are a team. The design firm is part of the client. Now the design firm is tighter to the contractor."* PM, Owner, Project A

The designers and contractors in both projects are agreeing that ECI leads to more holistic thinking and to solutions that are better suited for the specific project. They state that this is mainly because the designer needs to consider the buildability of the design as well as the contractor needs to focus on finding good solutions, rather than discovering flaws in the design. Furthermore, the contractor informants of both projects

mention that awarding the responsibility for maintenance to the contractor stimulates them to adapt a more holistic mindset. They argue that being responsible for both the building and the maintenance of the roads intentivize them to find solutions that will ease the maintenance work, and thereby reduce the life-cycle cost.

> *"I think that working together with the contractor challenges us in a positive way that we have to think different regarding concepts, design, economy, time frame. (...) We are more effective and we are delivering more, not always better solutions, but solutions better suited for the needs in the project."* PM, Design Firm, Project A

The contractors and designers mention that they find it challenging to work this close. The designers are not used to design according to the contractors needs, and the contractor is not used to manage the designers. One also mentions that the contractors and designers tend to have a different mindset. However, they also believe that this process will become easier over time. One of the informants, that has experience from both the design firm and the contractor, argues that the process of changing these roles can be eased if the contractor emphasizes on creating a good specification that will form the basis. Furthermore, he argues that bringing representatives from the building site into the design-process will grant better understanding of the construction processes amongst the designers.

> *"I think a lot of us, designers, are academic people we tend to over complicate some things, the contractor simplifies everything a lot."* PM, Design firm, Project A

> *"Our specification is the most important thing. But we also have to look into the design process. I think it a good thing when we bring in an experienced site worker in order to share his or her experience with the design team."* BIM responsible, Contractor, Project A

5.3.2 The need for a competent contractor

When asked whether it is important to have a competent owner in "contractor managed DB" projects, the informants say that it is more important to have a competent contractor. The owners and contractors are telling that the owner needs less employees in the case projects than in the traditional projects, because they emphasize more on checking the contractors quality and control systems rather than the actual work. The owner in project A mentions that they trust the contractor to a larger extend. On the contrary, the owner in project B says that this is not enabled by trust, but rather by the incentives and risks that the contractor has within the project. Other informants also explain that the contractor has more risk in a "contractor managed DB" because they manage larger parts in the contract. The contractors say that on the one side this gives

them the possibilities to earn more money, because they are able to implement efficient solutions. On the other side it makes them responsible if there are flaws in the design.

> *It gives us a different responsibility. We are accountable for a larger part of the project. The risk is larger, and one has to take more into consideration. However, it also gives us the possibility to earn more money, but also to loose money."* DM, Contractor, Project B

> *"In a classic project the owner has 50/60/70 people there, checking the contractor. Now we have 4. The contractor is controlling them self. (...) So we have to trust them and we take some check points in their system early in the contract period, to see if they have a system to check themselves*" PM, Owner, Project A

However, the informants also mention that it is important that the owner gives a good specification and is able to communicate their goal. The contractors in both projects mention that they believe that early involvement and a proper clarification phase helps them to better understand the owners goals. A designers at project A states that it is very important that the owner provides a good base document, because they will try to challenge them in order to save money. He underlines that this is especially important when there is a contradiction between the cheapest way of building and other factors such as environmental or landscaping perspectives. Similarly, the PM for the contractor in project A states that is is very important that the owners goals are embedded into the DB entity.

> *You have to see that those goals are important for the project, for all the parties, maybe for the local community and the other stakeholders. It is a combination of goals set by the client which we have to take part in, but it is also important in the start up. When we start to meet after the contract is signed, that we actually challenge these goals and discuss them and see what we are going to do to meet them together."* PM, Contractor, Project A

The informants are also telling that the contractor needs to manage to a larger extent the stakeholder than in traditional projects. They tell that the owner is still responsible for the large issues, like the acquisition of land, but that the contractor is responsible of discussing the details with third parties. The contractors and designers find the stakeholders management challenging, as they explain that some stakeholders have a political agenda. The subcontractor in project B tells that the stakeholders are willing to discuss solutions with them, but as soon at the project owner is in the meeting they are changing their mind and will try to demand more. The DM in Project A tells that it has been very difficult to handle other public stakeholders

that are affected by the projects, because they are not intentivized to cooperate with the contractors. The contractors in both projects calls for a more active owner.

> *"To buy houses and get access to the field and everything is the [responsibility of the] owner, so we do that. But to discuss details with them[the third parties] that is the contractor."* PM, Owner, Project A

> *"All the planning has to be done with "unnamed public organization" and that is challenging for many reasons. Not been taken care of in the early phase.(...) The frustration is that Owner has been to light on it in many terms."* DM, contractor, Project A

5.3.3 Giving the contractor the freedom to find good solutions

According to the owner in project A, the zoning plan was prepared for a DBB project. He says that a result of this was that the zoning plan was too specific and that it restricted the possibilities of the contractors. The owner believes that this problem could be solved by creating a zoning plan that is low in details and has a lot of free space. He states that this would make it possible for the contractor to choose the solution that gives the lowest cost and the lowest risk. In project B the contractor participated in the creation of the zoning plan. The contractors of project B, experienced this as a positive thing and says that this allowed them to make sure that the plan fitted for their machines methods. Furthermore, he experienced that there were fewer changes in the zoning plan than usual.

> *"The zoning plan was very detailed and that was a problem in a design build contract. We had to make a lot of changes in that zoning plan. So it was too narrow, to small to build, we need more space to build everything in a safe way."* DM, Contractor, project B

However, the owner in project B is explaining that they gave the contractor too much freedom. He states that since the contractor is running the design, the solutions revolved around the contractors need. He states that sometimes this leads to solutions that are different from what the owner intend. He also questions whether it is better to have the designers located on a higher level in the hierarchy, rather than to allocate them under the contractor.

5.4 Collaboration

The collaboration within a project is different than in a traditional project (see ch. 5.2). In this sub chapter, we are examining the challenges and possible measures related to the collaboration necessary in a collabo-

rative project. The focus does not only lay on collaboration in terms of communication, but also on building a team and creating an environment that supports collaboration. Therefore, we are dividing this subchapter in three sections with a focus on personal compatibility, start-up meetings and co-location.

5.4.1 Finding compatibility on the individual level is a challenge

The informants are in agreement that is it important to form a good team where people are able to collaborate with each other. They say the people have to be competent and willing to collaborate between companies and disciplines. This includes willingness and the ability to communicate with each other and trusting that each participant wants what is best for the project and not only for their own. One of the contractors says that it is about involving the right complementary people and competences to solve the problems. The PM of the design firm in project A adds that keeping a small project team, where all participants understand the participants and project goals thoroughly, is the most effective way of organizing a project.

> *"The personal chemistry between people is very important and also that tends to challenge better solutions for your work, both for the engineering and the actual work that has to be done."* PM, Contractor, Project A

The participants of project A mention that various key people, such as managers, have been changed during the project, because they were not compatible on the individual level. They say that the participants should be able to communicate well with each other and trust each other. By changing people in the core team, they explain that they could establish a team with competence, chemistry, and trust. However, the PM of the contractor in project A mentions that changing out people also lead to communication problems on a daily basis.

> *"We have switched a lot of people, both within the contractor and design firm. (...) Their personalities were too far away from each other and they just could not collaborate and communicate with each other. The current team is way better than the one we started with."* BIM responsible, Contractor, Project A

Having personal compatibility is also identified as an important aspect by the informants of project B. One of the designers in project B explains that they have kept the core team, thus they have not switched out the most important people between the different phases and that this leads to starting on a much higher level of collaboration than when new participants would be involved. He explains decisions made by the team early on are understood in the later phases when you continue with the same team. Additionally, he tells that the

project had good participants with a good team spirit which is a good resource for a good project. However, the PM from the subcontractor in project B says that participants, he was working close with, did switch or move on to other projects. He also mentions problems with the owner allocating too few people to follow up on the electrical work early in the project.

> *"One of the problems is that they are putting on resources within the electrical disciplines too late. We are working quite long without a real contact point in the project. Thus, we have to discuss with people that have limited knowledge of electrical issues. (. . .) If they put on people earlier that follow the electrical part of the project throughout the whole process, whom also have the mandate to make decisions then they can make decisions in design meetings. In this way it is not up for discussion later."* PM, subcontractor, Project B

5.4.2 Kick-off meetings are a communication starter

The informants are in agreement that to establish a good team, communication, trust and motivation have to be present. To establish this level of collaboration the core groups of both projects organized kick-off or ICE meetings in the start of the project. The owner of project A explains that they organized meetings to bring the participants together and to discuss and be part of each other's work. Both contractors and designers in project B mention that many people in the project joined the ICE meetings held in the beginning of the project. In addition, they organized various activities such as dinners to create an environment whereby informal communication is promoted.

> *"These meetings have been a kick starter for communication in the project, so in my opinion, starting conversation within and between groups is way much more difficult than keeping it. so the ICE sessions have been very essential."* BIM responsible, Design firm, Project B

The informants describe the kick-off meetings as enablers for better communication and trust among the participants. In addition, it allows the participants to get to know each other, the strengths and weaknesses of the team, and each other's processes. They tell that it ensures aligned and agreed upon project goals which are a motivation for each and one of them as well as it enhances the decision-making process, the BIM responsible of the contractor mentions. It also gives the possibility to challenge each other for better solutions in the project according to PM of the contractor.

> *"We had to use time to get familiar with working with the design team. I think it is necessary use this time, and try the collaboration. Use the time to get to know each other and find your place and role in the collaboration."* BIM responsible, Contractor, Project A

Even though all the informants have a positive view on the kick-off meetings and they say that without these meeting they would not have achieved the level of collaboration they reached, they explain that there has to be chemistry between the participants and willingness to collaborate. The informants of project A explain that this was not the case in their project and therefore they had to replace individuals. The PM of the subcontractor in project B mentions also that the team spirit goes slightly downwards over time in the project, regardless of the ICE meetings. He explains that this leads to difficulties in communication with some participants in later phases of the project. This is a contradiction of what the BIM responsible of the design firm of the same project says. He tells that the ICE meetings are a success factor of the established collaborative routines in the project.

> *"You have to know the people, you have to trust the people and you need to have all information open/transparent."* PM, owner, Project A

> *"It sounds maybe not too important, but it is actually very important, that people manage to solve problems together."* PM, contractor, Project A

5.4.3 Co-location enhances collaboration between the project participants

All informants agree that co-location enhances the collaboration in a project. The owner, contractor and designer sit in the same facility while working on the project. They mention that the co-location was very helpful in overcoming challenges and issues in the project, because they explain that working together in the same room gives the possibility to talk more easily and more frequent with each other. When issues occur, they can walk to the one responsible and discuss it. They also mention that informal communication gets enabled when they work in the same office with the other participants. The issues are discussed over lunch or a cup of coffee, instead of in a formal meeting. The PM of the design firm in project A says that co-location makes the participants more familiar with each other and the way of working, it also creates more interest and trust in each others work. However, the owner of project A beliefs that co-location is not necessary, but is does eases the communication processes.

> *"Being together in the same space or facilities and challenging each other; you get to know each other on a higher level and that is good."* PM, contractor, Project A

Even though co-location is overall perceived as positive, different informants from both projects mention that it creates some challenges. For example, one informant says that when issues are discussed in person, they are not entered in the communication platforms and thus not everyone is aware that the issue is handled.

Another informant in project B says that the participants are not yet used to the way of working when co-located. The BIM responsible of the contractor in project A explains that unnecessary questions are asked because it is easy to ask something when you see the responsible person in your office. This is backed up by the project manager of the design firm and the design manager of the contractor, of which the latter says that questions about details are a time thief, mainly in the later phases of the project

> *"It is challenging for us because we are not used to that way of communication. We are used to having some hours to think and to have a reasonable answer. Now we are challenged to be live and answer right away and it needs reason".* PM, Design firm, Project A

> *"In the preliminary phase it is very good to be situated at the same site, but not all the way through the construction, building time period."* DM, Contractor, Project A

5.5 Technology

One of the key entities in a collaborative project is the use of digital and 3D technology (see sub ch. 5.2). The informants say that there is a high demand to the use of digital modelling. In this sub chapter we will look into the challenges related to technology in the case projects. We will address standardization and functionality of models and open communication platforms.

5.5.1 Need for standardized modeling tools suitable for infrastructure projects

The amount of different technology utilized within the case projects are, in the words of an informant, "way too many". The contractors and designers from both projects explain that the reason for the extensive use of different platforms is that most software is created for the building industry, and therefore does not fit the infrastructure industry. They explain that the existing platforms lack functions that they need in their daily work.

> *There is a lot of standardization within the building industry, and the software is developed for building projects. We lack standardization and we lack tailor-made solutions for infrastructure projects.*" BIM responsible, Contractor, Project A

In addition to the large amount of variation of digital programs, the integration between these different programs is poor. The informants explain that programs lack the ability to mirror each other and that there is a risk that information will get lost when data is transferred between the programs. As a result of this, they use a lot of time translating information between the different programs and models. One of the contractors

in project B thinks that this makes it difficult to keep the models updated and that it often results in conflicts in the design process. Informants in both projects say that they think it is possible to overcome this challenge by creating a single platform that could handle all tasks. The PM of the contractor in project A argues that the problem could be reduced if the contractor specified which programs the consultants should use in the design.

> *"We had to transfer the information between, manually. When there is a lot to do, you do not prioritize to do these non-automated transfers. It is taking a lot of time"* PM, subcontractor, Project B

5.5.2 Challenging to obtain the right information in the models

The challenges of using digital models instead of drawings is perceived different among the actors. The informants in both projects tell that they have been provided training in the use of the new softwares. The owner in project A tells us that there are no problems with using the models and that the builders love it. However, the contractors and designers explain that they experience several challenges in relation to the transition from drawings to digital models. The designer in projects B says that the builders struggle to use the models as they are used to work with paper drawings. A contractor in project A mentions that they also experience this struggle, however they experience that the builders are willing to change and are able to find good solutions together. The representatives from the contractors mention also that the designers are not used to focus on the buildability of the models. The designers in both projects are saying that it is challenging to visualize the information that builders need in a good way. They are explaining that the models contain a lot of information and that the builders use a lot of time finding the information they need. This is supported by the informants of the contractors whom say that the builders on the site have difficulties finding the information they need to build due to an overflow of information in the model. Some of the informants say that they think the main reason for this problem is that the models do not contain a good way to visualise the information. The contractors in project A are also mentioning that the use of generic products in the design leads to flaws in the models. Because when the actual product arrives, it does not fit and adjustments need to be made. They believe that moving the procurement process to an earlier phase will give the opportunity to design with specified products and thereby the models will be more accurate.

> *"No one is actually thinking on whats actually going on. What does the guy that is running the excavator or laying the pipes actually need? (...) When they have the right tools and models the productions are much faster and safer and everything. There is to little focus on the creation of*

build-able 3D models or build-able design" BIM responsible, Contractor, Project A

Another challenge mentioned by all informants, in exception of the owner, is the issues of keeping track of revisions. The contractors are experiencing that the models lack the functionality to visualize changes in a good and quick way. They are explaining that the models are being updated continuously and that this makes it hard for the builders to catch all the revisions. They explain that with drawings it was clearly visible in a revision cloud, but now they have to look for the changes by clicking on subjects in the model. In section 5.6.2, *A good MMI system is necessary to keep track of a concurrent process*, we are explaining other problems related to larger revisions and the visibility of approved-to-build designs. The contractor in project A explains that there have been issues with designers that have revised elements that already were built, because the designers are not able to keep track of the builders progress. He thinks that this problem is a result of a lack of two way communication between the designers and the building site.

> *"All the way through the chain the models had to be updated at the right time, we experienced that revisions came after things were build. (...) it is important for the designer when they are doing changes to describe where and how the changes are done. It is frustrating when changes come after things are build."* DM, Contractor, Project A

5.5.3 Open communication platforms are not used enough

In both projects the informants are telling that there has been extensive use of digital communication platforms in the project. There is an agreement amongst them that the use of digital communication is influencing the information flow in the project in a positive way. They tell that the use of the platform replaces endless and untraceable email strings. Furthermore, it is explained that the platforms allow for issues to be allocated to specific elements in the models, and that relevant people can be tagged. The subcontractor in project B says that it allows people to follow discussions passively and to come with input where it is needed.

> *"When we use the digital platforms, the communication is good. Then you can follow the communication strings and see what is being discussed and see what problems other disciplines have. Then we can send in comments or suggest solutions, or describe problems."* PM, subcontractor, project B.

Even though the open communication platforms are perceived as positive, the informants explain that in order to utilize the benefits of the open communication platforms, it is very important that everyone is

actively using them, which is not always the case. They say that if someone takes out an issue and handles it on email, the communication is no longer open. This makes it hard for others to participate or trace the decisions. The contractors and designers are agreeing that there is too much communication outside the platforms. However, the DM of the contractor in project B is saying that he is handling the registration in the platforms for the site managers, as he thinks it takes way too much time if they were to do it themselves. He is also explaining that it is easier for him to follow up on the issues, when he is managing the issues in the systems himself. The subcontractor in project B is mentioning that they used different platforms for internal communication and external communication. He explains that this lead to problems in the communication between the actors, because the information was not visible for everyone.

> *"We have tried to use open communication platform to communicate with both contractor, stakeholder and design team. It is working good when everyone is using it, but I see that outlook is used instead of this communication platform."* PM, Design firm, Project A

The informants mention several different barriers towards the use of the open communication systems. Some informants are saying that motivation to change is the main barrier and that people are reluctant to leave their old ways. One of the participants in project B is explaining that the use of the platforms was high in the start of the project, when it was new and exiting, but it declined after a while. However, others are mentioning that availability is the most significant barrier. They explain that everyone has their email open at all times and an email can be sent instantly, while the communication platforms are several clicks away. The DM in project B also tells that it is more time consuming to post in the open communication systems, because the inquiries have to be added in the right way and need to contain detailed information regarding the object it is related to. The informants also agree that there is a lack of standardization and that the result of this is that people engaged in several projects will have to keep track of many different platforms.

> *"Jira is like four or five click away. And outlook is open during the whole day, so its easier to send a mail"* BIM responsible, Contractor, Project B

Some of the informants have suggested measures to overcome barriers and promote use of the communication platforms. The design manager in project B says that he thinks that increased standardization would promote the use as this would lead to fewer systems. One of the designers in project A tells that he has stopped answering emails regarding issues and is telling people to register the inquiries in the open communication platforms if they want it to be handled. Similarly, the subcontractor in project B says that he experienceS That the design management is demanding that the communication goes via open communication platforms.

" The design management is demanding that communication goes through Jira. If you ask them a question outside they will answer: Make a case in the Jira so other people can see it too." PM, Subcontractor, Project B

5.6 Concurrent Process

In a CPDS it is normal to start the building process at the same time as the engineers are designing the project. This is different than in a traditional project, where the contractor gets involved to start building after the design is finished. The informants had different perspectives on this concurrent process. In this sub chapter, we will present the perceived experiences on the concurrent process in two sections focusing on planning and model maturity.

5.6.1 Design needs a head start on the construction

Informants from both projects say that many activities and processes are executed in a short time period. One of the contractors in project B mentions that not only the building and designing was concurrent, but also the zoning plan, which was not ideal. He tells that the concurrent processes give a lot of organization, since certain tasks are dependent and there is a need for extra people.

"That is a challenge to be able to give everyone involved enough knowledge about the project, the goals, the contract. It tends to blow up a bit. The organisation gets a bit bigger than it needs to be." PM, design firm, Project A

The informants are explaining that an important part of a concurrent process are decisions of how much risk one is willing to take and how much effort to put in the design before you start building. The contractors tell that this leads to a risk of having to tear down parts and start over again and that they always have to asses the risk of starting with an incomplete design against the benefit of starting the construction early. The contractor in Project A says that there was a lot of trying and failing in the start. The owner, contractor and designers of project A are in agreement that they started building to early and as a result the design was lagging. They are explaining that this lead to a situation where the designers was always in a hurry in order to get the design ready and not stop the building process. The DM in Project B says that one of the biggest challenges of conducting a concurrent process is to make sure that the design stays ahead of the construction at all times in all disciplines, so that the construction can run continuously.

"The contractor set off too little time to do the design. So the design was late for the builders, so that was a problem." PM, Owner, Project A

The subcontractor in project B tells that they also experience problems related to the concurrent process. They experience that when several disciplines work on the same part of the project at the same time, but in different platforms, the designs do not fit when they come together in the shared model. He also mentions that they experience that some parts of the design are locked in earlier than expected because components like foundations and pipes are often constructed early in the project. This gives problems in the design and in the construction, because the designs have to be changed to fit together while parts might have been build already.

> *"We have the problem that we don't work in the same model. There are often happening a lot of changes between the time we take out the model and when we put the finished work back in. This leads to conflicts."* PM, Subcontractor, Project B

5.6.2 A good MMI system is necessary to keep track of a concurrent process

The informants of both projects are explaining that they work with a live model of the project. This model is accessible for all parties. The risk assessment of the designed models are shown with a Model Maturity Index, MMI, whereby 100 is a sketch of the design and 500 is a complete design. The PM of the design firm says that the designers are happy with the design and are willing to take the responsibility with an MMI of 400. However, due to the concurrent processes, the constructions starts at a lower MMI level at some points. The DM in project B explains that with different levels of MMI's the building work can occur in different stages, for example with a low MMI the area can be deforest and with a higher MMI the asphalt can be laid. The levels of MMI show a finished part of the project for certain work, but there is a risk that the design changes and work has to be redone if the designers have to make large changes in the design to create a higher MMI in the model.

> *"In theory, it should be possible to changes in things that already have been built, but in practice this is not always the case. Sometimes we have to take the risk in order to start early. Sometimes we encounter setback, but in the overall pictures it pays off."* BIM responsible, Contractor, project B

The PM of the contractor in project A says that they decided to start on a lower maturity than they should have and that this caused problems and challenges due to changes later on. Thus, when making changes to parts that were already build, the builders had to demolish and start over. That said, one of the designers in project B mentions another challenge related to the MMI. He explains that the MMI levels are not understood

by the people working at the building site. They see a part of the model and think it is finished, because they are not looking at the MMI level and they start constructing it. He says that the communication regarding the MMI levels from the design office to the building site is insufficient.

> *"We as consultant have been using the MMI to show what is approved and what is not approved by the contractor, so it is shown in the model but the builders don't understand MMI levels. They just have a look at the model and they think this should be build and then the model is changed next week because that was just a sketch."* BIM responsible, Design Firm, Project B

The BIM responsible informants present some possible solutions of the challenges related to MMI. One BIM responsible suggest that the information should be more visible instead of clickable, so the builders see which part of the model is ready to be build and which that are not. Another suggests that the design and construction model should be split. In this way the builders will only be able to see the design with a high MMI and thus the risk of starting to build elements that are not ready will be greatly reduced.

> *"The construction guys don't need to see everything that is going on in the design. Because the design is an iterative process that is slowly moving forwards by sharing and doing changes. So we will have to implement a better MMI system, that after the MMI is 350 the construction guys can see everything."* BIM responsible, Contractor, Project A

6 Analysis

In this chapter we are evaluating the theoretical propositions created in chapter 3, *Challenges with Collaborative Project Delivery*, based on the empirical findings presented in chapter 5, *Empirical Findings*. The intention of this chapter is to asses the propositions and in doing so to form a foundation for answering our research question, *"How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?"*. The chapter will be divided based on the three main elements of the ECT framework, Early Contractor Involvement, Collaboration, and Technology. Finally, the chapter is concluded with a summary, where we update the ECT framework based on our analysis.

6.1 Early Contractor Involvement

In sub chapter 3.1, *Early Contractor Involvement*, the challenges related to ECI were examined. The challenges were divided into three main issues: team forming, project definition and role restructuring. We suggested four proposition which we are analyzing with the empirical data from chapter 5, *Empirical Findings*, in this sub chapter

6.1.1 E1: Competent participants

> E1: *The owner's ability to form a good team is important in projects that utilize Early Contractor Involvement.*

In section 3.1.1, *Team Forming*, theory was presented that illustrates that the owners ability to set up a good project team is important in a CPDS. Roy et al. (2018) and AIA California Counsil (2007) reason that to be successful with ECI, an owner that is risk tolerant and competent in team forming is important. The importance of selecting the right project participants are also highlighted Ghassemi and Becerik-Gerber (2011).

From section 5.3.2, *The need for a competent contractor*, the majority of the informants argue that a competent contractor is way more important than a competent owner. They explain that the owner transfers a substantial amount of both risk and task to the contractor. Furthermore, it is stated that the owner needs fewer people to control the project, as it is expected that the contractor conducts project control and reports to the owner. Similarly, from 5.3.1, *Contractor takes a managing role*, the informants argue that the contractor takes a more managing roles in collaborative projects, because they are in charge of establishing the DB entity. Thus, ultimately the contractor is responsible of establishing a project team that is able to conduct the project in an efficient manner.

On the other hand, in section 5.3.2, *The need for a competent contractor* the representatives for the contractors and designers expressed that they find it important that the owner provide them with thorough specifications and base documents. It is also described that this is especially important when there is a contradiction between the cheapest and best way of solving a problem. Thus, it seems like the transfer of risk and responsibility is perceived as a double edged sword. On the one hand, it allows the contractor to utilize their expertise to conduct the project in a more efficient and cost effective way. On the other hand, one might argue that the contractor is incentiviced to choose the simplest and cheapest solutions in order to maximize their own profit. It is also stated that the owner controls the contractors quality systems rather than the actual work (see section 5.3.2). This requires that the owner possesses knowledge and insights on how such systems can be used to ensure that the end product maintains the intended level of quality.

Based on the previous, we assess the proposition E1 to be partially supported. On one side, the empirical data points heavily towards the importance of having a competent contractor, thus one might argue that this reduces the need for a competent owner. On the other side, one might argue that a competent owner is necessary in order to transfer the amount of tasks and responsibility and still achieve project goals. Although the competence required for this is difference from the competence of the owner in a traditional project. Based on this we revise proposition E1 to **The contractor's ability to form a good team is important in projects that utilize Early Contractor Involvement.**

6.1.2 E2: A good project definition is important when using ECI

> E2: The creation of a good project definition is important in projects that utilize Early contractor involvement.

The theory presented in section 3.1.2, *Project Definition*, illustrates that ECI promotes collaborative decision making and can lead to a better understanding of the project definition and the owners requirements (Hoezen, 2012; Roy et al., 2018). It also illustrates that ECI leads to an increased need for communication between the participants and an increased need for a clear project definition to ensure agreement and understanding among all participants (Aapaoja et al., 2013; Ebrahimi and Dowlatabadi, 2018; Hoezen, 2012; Roy et al., 2018).

From section 5.3.2, *The need for a competent contractor*, we can derive that the informants perceive that

ECI allows the contractor to improve their margins, because they are able to implement more efficient solutions. However, they also tell that this intentivizes them to do things in the cheapest way possible. In relation to this the informants argue that a good project definition is very important, especially when there is a contradiction between the best solution and the cheapest solution. The owner in project B supports this, and states that the contractor uses the designers in a different way than they would do, and as a result they did not always get the solutions they intended (see section 5.3.3). From this we can derive that it is important that the owner creates a well defined project definition.

We can read in section 5.3.3, *Giving the contractor the freedom to find good solutions*, that project A encountered problems because the project was initially planned as a DBB project. As a result the initial documents were too detailed and it restricted the contractor's possibility to leverage their expertise to create a more efficient project.

Based on this we assess that proposition E2 is partially supported. The creation of a good project definition is important when using ECI. Furthermore, a good project definition is characterized by having enough detail to ensure that the owner gets the intended product and at the same time leaving enough room for the contractor to use their expertise to improve the project. The original proposition does not cover all of these details. Thus, we are revising it to: **The creation of project definition, with a level detail that describe the projects deliverables and at the same time allows the contractor to use their expertise to improve the project, is important in projects that utilize Early Contractor Involvement.**

6.1.3 E3: ECI leads to a restructuring of the roles

E3: *Early contractor involvement leads to a restructuring of the traditional roles.*

The literature presented in section 3.1.3, *Role Restructuring*, illustrates that involving the contractor in the early phases means that project participants will have to engage in new activities. E.g the architect has to engage in tasks related to engineering and construction (Abdirad and Dossick, 2019), while the contractor has to engage in designing activities (Heravi et al., 2015). As a result the project participants might experience that they need to take on different roles.

In section 5.3.1, *Contractor takes a managing role*, we can read that the contractor takes a more managing role. The informants tell that the collaboration between the contractor and designers was much closer

than they were used to. This meant that the designers to a larger extent needed to consider the buildability of their design. Furthermore, they tell that the contractor had to change their focus from searching for flaws in the design to avoiding these flaws by finding good solutions. The informants also tell that the contractor is responsible for managing the designers and the design process. Whereby the contractor needs to make sure that the designers have enough time to create a buildable design before the construction starts (see section 5.6.1) Moreover, from section 5.3.2, *The need for a competent contractor*, we can see that the need for people from the owner is greatly reduced in collaborative projects. In traditional project the owner uses a lot of resources to control the contractors, while in collaborative projects the owners emphasizes on checking the contractors quality and control systems. Thus, the activities related to controlling the building process is to a large extent relocated from the owner to the contractor.

Based on this, we assess that ECI leads to a restructuring of the traditional roles. Thus, proposition E3 is supported.

6.1.4 E4: A facilitator will ease the transition from Traditional to Collaborative Project delivery

> *E4: A facilitator will ease the transition to a CPDS in projects where the participants are inexperienced with this way of working.*

From section 3.1.3, *Role Restructuring*, we can read that some authors recommend the use of a facilitator in projects where the participants are inexperienced with CPDS (Abdirad and Dossick, 2019; Fish and Keen, 2012). It is argued that the use of a facilitator creates an efficient project. It can be fulfilled by an external party or by one of the key participant whom has experience. In that case all participants should be able and willing to take on the facilitator role when required (Fish and Keen, 2012).

Our empirical data shows that there is a shift in responsibilities and that the contractor and designers are working more closely than they were used to (see section 5.3.2). The informants tell that they find this challenging. One of the informants argues that a facilitator could be used to overcome this (see section 5.3.1). He argues that the facilitator should be someone from the outside and have a broad experience from working as a owner, contractor and designers in order to take on the role. However, none of the other informants mentioned the use of a facilitator or issues that are related to it.

The evidence we have collected point towards that the use of a facilitator might influence collaborative

projects in a positive way. However, due to the scarce data we are not able to draw any conclusion on whether proposition is supported or not. Thus, proposition E4 is inconclusive.

6.2 Collaboration

The challenges related to collaboration were presented in sub chapter 3.2, *Collaboration*. We divided the challenges into three subcategories: communication, trust and motivation. Based on the presented theory, we proposed three propositions which we are analyzing in this sub chapter.

6.2.1 C1: Open communication can be established through multiple measures

> C1: *The use of measures to enhance open communication is necessary to establish collaboration.*

The theory presented in section 3.2.1, *Communication* illustrates that open communication among all participants is a necessity for good collaboration and, consequently, to a more efficient infrastructure project. The theory explains open communication as information that is clear, direct, transparent, and trusting (AIA California Counsil, 2007). Communication protocols (AIA California Counsil, 2007), co-location(Aapaoja et al., 2013; Alves and Shah, 2018), and kick-off meetings (Engebø et al., 2020b,a) are suggested as individual measures to establish open communication by various authors. The theory suggest also that digital integrated platforms can enhance communication (Azhar et al., 2014; Shen et al., 2010).

Our empirical data shows that the informants perceive communication as important as they mention participants should be competent, willing and able to communicate to collaborate. In addition, section 5.4.1, *Finding compatibility on the individual level is a challenge*, suggests that enabling communication between all participants and thus involving them actively from the start is important to avoid discussions or disputes later on. The contractors explain that for the project understanding it is important that the owner gives good project specifications and is able to communicate the project goal (see section 5.3.2). Whereas one informant explains that the contractor should emphasize on creating good specification for the project towards the designer (see section 5.3.1). In short, it seems that clear communication should go from owner to contractor and from contractor to designer. In section 5.3.2, *The need for a competent contractor*, stakeholder management is briefly discussed. We can derive from this section that open, clear and trusting communication is important, because when stakeholders say different things to different people or at different moments, it is harder to clarify and decide on aspects of the project. The informants explain that they undertake different

activities within the project, such as co-location (see section 5.4.3), kick-off meetings and informal activities (see section 5.4.2), to enable communication and collaboration. These activities bring them together, make them more familiar with each other and their work processes as well as it enables informal communication. All these activities enables the open communication within their project.

It is implied by section 5.5.2, *Challenging to obtain the right information in the models* that the use of technology can create challenges in communication among the different levels in an infrastructure project due to misunderstanding of models and an overflow of information. The contractor can specify which digital platforms and software should be used among participants, as an informant stated in section 5.5.1, *Need for standardized modeling tools suitable for infrastructure projects*. This can prevent loosing or misunderstanding information when transferring it between different programs. In section 5.5.3, *Open communication platforms are not used enough*, the informants say that communication platforms enable open communication when they are used in a sufficient way. However, project participants are using different platforms for internal and external communication and different projects, as well as they switch to email or in person communication due to co-location. This disrupts the openness of the communication. The informants suggest that it can be overcome by promoting or demanding the use of a standardized open communication platform.

Our study shows that the participants see the importance of good communication, thus collaboration, and that they try to establish open communication in various ways within their projects. Based on the empirical data, we see that the participants implement multiple measures to balance out the weaknesses of each measure. For example, the open communication that is established by kick off meetings can be ensured to continue by a communication protocol. As well as, technology can enhance visualization of information within meetings or when working together co-located. Therefore, we assess the proposition C1 partially supported. Our study supports that it is important to use measures to establish open communication, but addresses the need of using multiple measures. Thus, we revise the proposition C1 to **The use of multiple measures to enhance open communication is necessary to establish collaboration**

6.2.2 C2: Trust can establish collaboration in a CPDS

C2: *Building trust among the participants is vital to enable collaboration.*

In section 3.2.2, *Trust*, we presented theory that stresses the necessity of trust in a project team that collaborates on a high level. We presented the theory on contractual trust, the use of incentives (AIA California

Counsil, 2007), and relational trust with the latter split into preexisted trust and forced trust (Aapaoja et al., 2013; Ghassemi and Becerik-Gerber, 2011). Preexisted trust is trust that build over time and forced trust is trust that can be established by tools and activities (Ghassemi and Becerik-Gerber, 2011), such as co-location (Ghassemi and Becerik-Gerber, 2011) and kick-off meetings (Engebø et al., 2020a) to stimulate communication, information sharing and understanding of each others work processes.

From the sections 5.4.1, *Finding compatibility on the individual level is a challenge* and 5.4.2, *Kick-off meetings are a communication starter*, we can read that the informants say that it is important that there is trust among the participant. They have to trust that each and one of them works towards what is best for their project and not what is best for their own. Nevertheless, the informants know that it takes time to get familiar with each other, each other's work processes and to find their place and role within the collaboration. In section 5.4.2, *Kick-off meetings are a communication starter* the rational behind kick-off meetings is addressed. The informants tell that such meetings are used to create trust among participants, to get to know each other, to get to know the strength and weaknesses of the participants as well as each other's work processes. The latter is also stated as a result from co-location, discussed in section 5.4.3, *Co-location enhances collaboration between the project participants*. By working in the same facility they get familiar with each other and their way of working, thus it creates more trust and interest in each other's work. This shows that the projects use activities to create trust early on among the participants.

In section 5.3.2, *The need for a competent contractor*, the trust between the contractor and the owner is addressed. The owner in project A mentions that they trust the contractor for a larger extend in being able to do the work and that they use less people in the project because they only follow up and do quality and control checks. Whereas the owner in project B explains that their relation is not based on trust, but on contractual incentives. The contractor is incentivized to deliver a good project with monetary incentives and the transfer of risk and responsibilities.

Based on the previous, we assess the proposition C2 supported. The informants show interest and understanding of the importance of trust within a project team. Even though they do not have preexisting trust, they find different ways and activities to build trust, such as kick-off meetings and co-location, and thus utilize forced trust. Furthermore, the data also show that trust is not only build by activities, but that incentives and transferred risks also creates trust.

6.2.3 C3: Motivation alone is not enough to collaborate

C3: *Motivation is necessary to establish collaboration.*

The theory on motivation to collaborate is presented in section 3.2.3, *Motivation*. It explains that motivation to collaborate is necessary to establish the level of communication and trust required in an CPDS (Azhar et al., 2014; Ebrahimi and Dowlatabadi, 2018). The reasons for unmotivated participants can be a traditional mindset, no or misunderstood incentives or unawareness of collaboration and its benefits within a CPDS (Aapaoja et al., 2013) as well as incompatible personality (Ebrahimi and Dowlatabadi, 2018).

The informants agree that people need to be competent and willing to collaborate together between companies and disciplines discussed in section 5.4.1, *Finding compatibility on the individual level is a challenge*. As one informant states that a good team spirit is a good resource for a good project. Another informant adds that over time the team spirit went down and that this influences the collaboration, negatively (see section 5.4.2). From section 5.3.1, *Contractor takes a managing role*, the informants explain that the way of working is still new and that they have to learn how to work in a project organized as a contractor managed DB. It seems as if they are very motivated to learn how to collaborate and to work as efficient as possible in this new way of working. This applies also to the motivation from the builders to find solutions with the inexperience they have with models and technology (see section 5.5.2). In addition, there are incentives present to motivate the participants to deliver a good project.

Section 5.4.1, *Finding compatibility on the individual level is a challenge* presents the explanation of the informants on the importance of achievement of personal chemistry between the individuals. As a contractor says that without chemistry it becomes much harder to solve problems together (see section 5.4.2). In project A various key individuals have been changed during the project, because they were not personal compatible. Due to changing these individuals they established a team with competence, chemistry, and trust. In project B, they have not changed out people in the core team and this is argued as the reason they had a high level of collaboration. The kick-off meetings and co-location have been a good way to enable participants to communicate and let them get familiar with each other, consequently, to identify personal chemistry (see section 5.4.2). In section 5.4.1, *Finding compatibility on the individual level is a challenge*, we can read that when people change within the team, it can lead to communication problems on a daily basis. Based on this, we suggest that kick-off meetings or similar activities should be continued or repeated when participants get replaced in the team, to develop trust and familiarity among the new participants.

These findings show that motivation has been important within the case projects. The informants mention willingness and motivation to establish communicate and trust, and thus to collaborate with each other. However, the informants have been very clear that besides motivation also personal chemistry is very important within a project team. Therefore, we assess the proposition C3 as partially supported and revise it as follows: *Motivation and personal compatibility is necessary to establish collaboration.*

6.3 Technology

In sub chapter 3.3, *Technology*, the challenges related to the use of technology were examined. The challenges were divided into two main issues: interoperability and inexperience. We suggested two proposition which we will analyze in this sub chapter.

6.3.1 T1: Interoperable digital platforms enhances communication

> T1 *The implementation of interoperable technology platforms enhances the communication in collaborative projects.*

According to the literature in section 3.3.1, *Interoperability*, the use of advanced 3D modelling technology gives the ability to enhance the information flow and communication flow between the project participants. However, in order to achieve this, several authors emphasize that the platforms must be interoperable (Azhar et al., 2014; Shen et al., 2010). Furthermore, Ebrahimi and Dowlatabadi (2018) say that projects only reach partial integration with digital collaboration technologies. This can be due to the different requirements for the different segments of a infrastructure project.

From section 5.5.1, *Need for standardized modeling tools suitable for infrastructure projects*, we can read that there was an extensive use of 3D modelling platforms and open communication platforms in both case projects. Moreover, in section 5.5.3, *Open communication platforms are not used enough*, we present that the informants agree that the use of these platforms for digital communication has influenced the information flow in a positive way. We can also read that the informants mention several challenges related to interoperability. With regards to the modelling software, the general impression amongst the informants is that there are too many different platforms and that the platforms lack the ability to work together(see section 5.5.1). As a result a lot of time is used to transfer and translate data between the different platforms. The informants argue that the problems could be overcome by developing one platform that can handle all tasks.

Also one of the informants argue that the problems related to interoperability could be reduced, if they had specified which platforms they should use, early in the project. With regards to the open communication platforms, the informants perceive a lack of use to be a bigger problem than interoperability (see. section 5.5.3). However, the PM of the subcontractor in Project B tells that they used different platforms for internal and external communication, and he argues that this lead to problems in that communication.

Based on the previous, we asses that the use of digital platforms for 3D modelling and open communication is important to establish communication in collaborative projects. However, in order to harvest the intended benefits the platforms needs to be integrated and work together. Thus, we asses that proposition T1 is supported.

6.3.2 T2: Communication is key when using 3D modelling platforms in Collaborative Projects

> T2 *Training within the chosen 3D modelling platforms is the most important factor in order to utilize the full potential of technology in a CPDS.*

The theory in section 3.3.2, *Inexperience*, illustrates that training is required if the full potential of the 3D modelling platforms are to be utilized (Merschbrock and Munkvold, 2015; Kapogiannis and Sherratt, 2018). Kapogiannis and Sherratt (2018) say that when participants understand the used software, coordination of tasks can be enabled and discrepancies can be reduced with 3D design. However, when participants lack the understanding this will be difficult to achieve. Kent and Becerik-Gerber (2010) also mention that there can be challenges related to how to use the technology to collaborate.

From section 5.5.2, *Challenging to obtain the right information in the models*, we see that both builders and designers are willing and able to use the new technology platforms. The informants in both projects tell that there have been provided training in order to implement the new technology. One of the owners is telling that there have been no problems with regards to the use of technology. However, the informants representing the contractors and designers list several problems related to the new modelling technology. The designers state that it is challenging to visualize the information for the builders at the building sites. Similarly, the representatives for the contractor describe that their impression is that the models contain a lot of information and that this creates an information overload. The informants argue that the main reason for this is that the software lacks a good way to visualize the information. We can also read that the informants have experienced issues related communicating revisions of the models to the building site. They explain

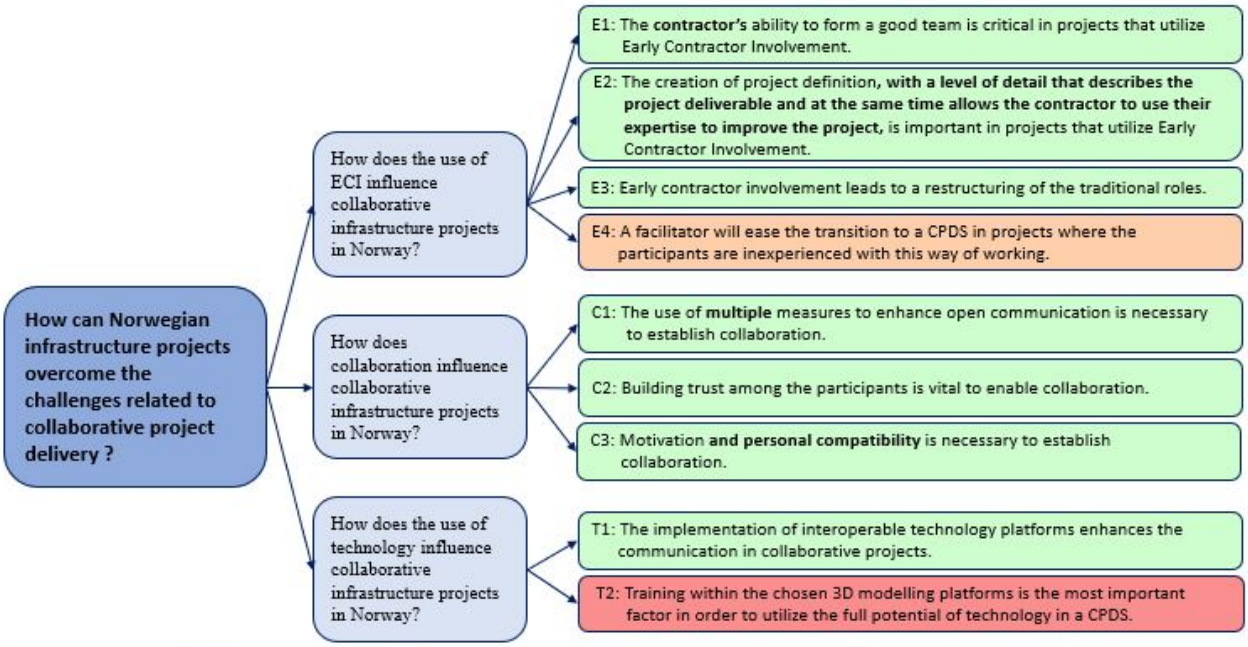
that the creating a model is an iterative process, and that there is being made a lot of changes. However, when the building of the different elements started, the room for changes in the design is closed. One of the informant tells that there has been a lack off communication between the designers and the building sites. As a result, the designers do not have an overview on where the builders are working and have tended to revise elements that were already built.

In chapter 5.6.2, *A good MMI system is necessary to keep track of a concurrent process* we can read that both projects have implemented a MMI systems to keep track of the concurrent process, and to ensure that the construction does not start before the design is ready. However, one of the designers tells that the builders do not understand the MMI system, and that everything that appears in the model is ready to build. To counter this, another informant suggest that the design and the construction models should be split, and that only the elements that are ready for construction should appear in the builder's models.

Based on the previous, we can see that the informants do not emphasize training when they are asked about challenges related to the use of modelling technology. Instead, they are mentioning lack of good procedures for handling revisions and information in the models. Furthermore, there seems to be a lack of communication between the building site and the designer with regards to the elements in the model. Based on this proposition T2 is not supported. However, this does not mean that training with the chosen platforms is not important, it rather highlights that in our case-projects procedures and communication are perceived as more important.

6.4 Summary

We evaluated the theoretical proposition that were created in chapter 3,*Challenges with Collaborative Project Delivery*, based on the findings presented in 5,*Empirical Findings*. When, evaluating the theoretical propositions we aimed to examine whether they are supported by the empirical data or not. However, in some cases the empirical data has provided an extra level of detail to the proposition. Therefore, we have revised these propositions. The results of the analysis is presented in figure 7, *The ECT framework with revised propositions*, which is an revised framework from our ECT framework given in sub chapter 3.4, *Summary*



ECI		Collaboration		Technology	
E1	**Revised**	C1	**Revised**	T1	Supported
E2	**Revised**	C2	Supported	T2	Not supported
E3	Supported	C3	**Revised**		
E4	Inconclusive				

Figure 7: The ECT framework with revised propositions

7 Discussion

In the previous chapters, we presented existing theory on collaborative project delivery, the empirical data from our case study, and an analysis of our theoretical propositions. In this chapter, we are examining the theoretical contribution of our research and analysis. We are comparing existing theory with our findings to see whether it coincides. Moreover, we are assessing how the propositions can contribute to answer our sub research questions. Consequently, this will create a foundation for answering our research question, *"How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?"*. The chapter is structured as per the elements of the ECT framework. In the first three sub chapters, we are placing our findings within the existing theory to discuss the theoretical contribution of our study. This is discussed by the means of our revised propositions from our ECT framework in figure 7, *The ECT framework with revised propositions*, as well as the related sub research question are taken in consideration. Finally, we are concluding the chapter by answering the three sub research questions.

7.1 Early contractor involvement

ECI is the first main element that we are discussing. The sub research question is: *"How does the use of ECI influence collaborative infrastructure projects in Norway?"*. The discussion in this sub chapter is covering the theoretical implications of the propositions regarding ECI.

7.1.1 E1: The contractor should focus on team forming

> E1: *The **contractor's** ability to form a good team is important in projects that utilize Early Contractor Involvement.*

In section 6.1.1, *E1: Competent participants*, we revised the original proposition E1 to shift the focus from the owner to the contractor, because our empirical findings indicate that the contractor is more important than the owner in relation to team forming.

Several authors argue that integrated projects teams are important and that all participants must be competent and committed (Rahman and Alhassan, 2012; Aapaoja et al., 2013; Ebrahimi and Dowlatabadi, 2018). Our findings are in line with this statement. The informants tell that they think that ECI promotes holistic thinking. However, it is also indicated that the designers and contractorS find it challenging to work closely together. Thus, we asses that the forming of a project team is important in order to harvest the benefits of ECI. Roy et al. (2018) and AIA California Counsil (2007) state that it is important to have a competent and

risk tolerant owner that is capable of establishing a good project team. Engebø et al. (2020b), on the other side, argue that it is important that the project team is given the autonomy and authority to make decision within the project. From the analysis we can see that our data is most in line with Engebø et al. (2020b), as the informants argue that it is much more important to have a competent and risk tolerant contractor. Our findings also indicate that the owner transfers a large amount of the risk to the contractor. Thus, our findings support the statement of Engebø et al. (2020b) and question the statements of Roy et al. (2018) and AIA California Counsil (2007). On the other hand, the analysis does not totally disregard the importance of the owner. Our findings show that informants perceive that the contractors often are inclined to choose the cheapest and simplest solution in order to maximize their own profit. Thus, to avoid this the owner must ensure to put mechanisms in place to ensure that the end product holds the intended quality.

Based on the findings from our case study, we conclude that the contractor is the most important participant in relation to team forming. The existing theory either emphasizes the need for competent participants (Aapaoja et al., 2013; Ebrahimi and Dowlatabadi, 2018), or the need for a competent and risk willing owner (AIA California Counsil, 2007; Roy et al., 2018) when discussing team forming. As a result, we asses that there is a lack in the existing theory as we find that it puts too little emphasis on the contractor's role. One explanation for this might be that our findings are specific to the Norwegian infrastructure industry or contractor managed DB. Still, according to Hussein (2018) and Samset (2014) the owner tends to focus on achieving the long term goals of the project, while the contractor tends to focus on issues related to the design and construction itself (see section 2.1.1). These arguments coincide with our findings as they imply that a process like team forming is mainly in the interest of the contractor. This raises the question 'why is the existing theory not focus on the contractor?'. One explanation is that ultimately it is the owner who decides which PDS to use. Thus, from a strategic perspective it will be much more effective for researchers to emphasize on the owner if they want to promote change. Anyhow, we conclude that team forming is an important issue when using ECI and that to overcome this it is important to use a contractor that is competent in team forming.

7.1.2 E2: The project definition should provide both freedom and control

The creation of project definition, with a level detail that describe the projects deliverables and at the same time allows the contractor to use their expertise to improve the project, is important in projects that utilize Early Contractor Involvement.

We assessed proposition E2 to be partially supported because we found that the main body of the original proposition was supported by our empirical data (see section 6.1.2). However, we perceived the proposition to be too superficial and it did not catch the essence of the details from our empirical data. Consequently, we revised the proposition. Our findings indicate that a good project definition is important when using ECI. The findings also imply that the project definition serves two missions in a collaborative project. The first is to describe the projects deliverables and their quality. The other is to provide the contractor the freedom to come up with solutions to improve the project.

From section 3.1.2, *Project Definition,* we can see that there is a general acceptance in the existing theory that a good project definition is important in order to transfer information regarding the owner's needs and project objectives (Aapaoja et al., 2013; Ebrahimi and Dowlatabadi, 2018; Hoezen, 2012). Our findings are in line with this as it also emphasizes the importance using the project definition as a way to ensure that the project achieves the intended goals and the end impression. However, our findings also indicate that it is important that the project definition leaves enough room for the project team to use their expertise to improve the project. The existing theory states that ECI leads to improved buildability, because it enables the implementation of the builders input in the design process. However, it does not mention that the project definition must give the project team the freedom to make changes.

Based on our case study and the analysis in section 6.1.2, *E2: A good project definition is important when using ECI*, we assess that the need for freedom in the project definition is under-communicated in the existing theory on CPDS. The reason for this might be that in full-fledged CPDSs the designer and the contractor are on the same level and the owner is more involved throughout the whole process (see chapter 2). Thus, reducing the need for the freedom in the project definition. Another explanation might be the cultural aspect. As the Scandinavian countries are perceived to have very high levels of trust in their society (Marozzi, 2015). Consequently, we find it likely that Norwegian culture emphasizes less on control than e.g. the American culture, which the bulk of the IPD theory originates from. Thus, Norwegian informants may be more inclined to emphasize on issues related to the lack of freedom. Therefore, one might question whether the finding is relevant outside contractor managed DBs and the Norwegian infrastructure industry. Nevertheless, we think the finding is important when discussing collaborative infrastructure projects in Norway.

7.1.3 E3: ECI leads to a restructuring of the roles

E3: *Early contractor involvement leads to a restructuring of the traditional roles.*

In section 6.1.3, *E3: ECI leads to a restructuring of the roles* we assessed that proposition E3 was supported because our empirical data indicates that there is a need for new roles in projects where ECI is used.

There seems to be a general agreement in the existing theory that the use of ECI leads to a restructuring of the roles and processes in the project (Abdirad and Dossick, 2019; Ebrahimi and Dowlatabadi, 2018; Heravi et al., 2015; Whang et al., 2019), (see section 3.1.3). The findings from our case study supports this agreement, as our informants tell that they are not used to work in this way and that they have engaged in new tasks and roles when working on the case projects. Moreover, they also mention that they need to consider the processes of the other participants. E.g. the designers need to consider the buildability of their design. At the same time, the contractor needs to make sure that the designers get enough time to prepare the necessary documents before the construction starts. The informants also mention that it can be challenging to take on the restructured roles.

Based on our findings, we asses that the existing theory is valid in collaborative infrastructure projects in Norway. The findings also indicate that the restructuring leads to a more holistic perspective, as the participants have to consider each others processes.

7.1.4 E4: The facilitator should be external and have extensive experience

> *E4: A facilitator will ease the transition to CPDS in projects where the participants are inexperienced with this way of working.*

In section 6.1.4, *E4: A facilitator will ease the transition from Traditional to Collaborative Project delivery* proposition E4 was found to be inconclusive, due to the lack of data. However, the data we did collect points toward supporting the proposition.

Abdirad and Dossick (2019) and Fish and Keen (2012) argue that the use of a facilitator might be necessary to create an efficient project when the participants are inexperienced with CPDS. Fish and Keen (2012) state that the facilitator could be an external party or one of the key participants. Our findings indicate that the use of a facilitator might be useful when setting up collaborative projects. Our findings also imply that the facilitator should be an external party and have extensive experience within from working as both an owner, a designer and a contractor.

Our findings are in line with Abdirad and Dossick (2019) and Fish and Keen (2012), thus supporting that a facilitator might be valuable. However, our empirical data is more descriptive with regards to the competence of the facilitator. Fish and Keen (2012) simply emphasize that the use of a facilitator is valuable in it self. While our findings emphasize that the facilitator should be an external party with extensive experience from the AEC industry. However, our data foundation is very scarce, as only one informant mentioned the facilitator role. This, might indicate that the other informants either find other factors to be more important than the use of a facilitator or that they do not have experience with the use of a facilitator. Nevertheless, based on the theory and our analysis, we find it to be likely that the use of a facilitator might ease the process of setting up a collaborative project. However, more research is needed in order to verify this as we discuss in sub chapter 8.5, *Further research*

7.2 Collaboration

Collaboration, the second element, is discussed in this sub chapter. The sub research question related to collaboration is as follow: *"How does collaboration influence collaborative infrastructure projects in Norway?"*. In this sub chapter, the theoretical implications of the propositions related to collaboration are discussed.

7.2.1 C1: Open communication is established through multiple manners

> C1: *The use of **multiple** measures to enhance open communication is necessary to establish collaboration*.

We assessed the proposition C1 as partially supported in the conclusion of section 6.2.1, *C1: Open communication can be established through multiple measures*, and revised it accordingly. Because communication is perceived as important among the informants and multiple activities such as co-location, kick-off meetings, and other informal activities are used to enable open communication in the projects. In addition, are communication protocols suggested as a means to ensure open communication during the entire project. As well as, technology, such as communication platforms, are utilized to enhance communication.

The theory argues that there are different ways to establish open communication in a collaborative project, such as co-location (e.g. Aapaoja et al., 2013), kick-off meetings (Engebø et al., 2020a,b) and communication protocols (AIA California Counsil, 2007; Butt et al., 2016) (see section 3.2.1). These authors propose them as individual measures that can be implemented to create open communication. In addition, Kapogian-

nis and Sherratt (2018) argue that technology can also enhance communication. Our findings agree with the theory as the informants mention that they have used both kick-off meetings, co-location and digital communication platforms as measures to establish communication in the case projects. However, our findings indicate that they should be treated more as a package than individual measures. E.g. an informant tells that when co-located people tend to communicate in person rather than within the digital platforms. This leads to disruption of open communication for other participants. He suggests that if a communication protocol had been in place, this could have been avoided. Hence, when using multiple measures, flaws of one measure can be complemented by another and so continuous, open communication can be ensured.

Based on the previous paragraph, we acknowledge the importance of the measures mentioned in the existing theory. However, we also assess that the existing theory is lacking a holistic perspective on the measures, as our findings indicates that the combined use is superior to individual use. The findings are based on two case projects in the Norwegian infrastructure industry and both projects utilized the measures in combination. Thus, we were not able to compare our findings to a project where they only utilized one measure. Thus, one might argue that our conclusion is drawn on a weak foundation. On the other hand, the fact that both projects use multiple measures, strengthens this conclusion.

7.2.2 C2: Trust can be build by activities and incentives

C2: *Building trust among the participants is vital to enable collaboration.*

In section 6.2.2, *C2: Trust can establish collaboration in a CPDS*, we assessed proposition C2 to be supported. Our empirical data supports that creating trust is an important factor for establishing collaboration and that it can be build by utilizing relational as well as contractual trust.

There is an agreement on the importance of trust within a project team in the existing theory (e.g. AIA California Counsil, 2007) (see section 3.2.2). Our informants are also addressing the importance of trust, thus, our empirical findings coincides with this agreement (see section 5.4.1). The theory describes two kinds of trust, contractual trust and relational trust. Contractual trust can be created through risk and reward sharing, because this aligns the projects interest and the interest of the participants (AIA California Counsil, 2007). Relational trust is build over time and by working closely together (Engebø et al., 2020a; Kent and Becerik-Gerber, 2010) (see section 3.2.2). Our findings indicate that both kinds of trust are important. On the one hand, the informants tells that they believe that trust within the project team is important. We can

also see that they emphasize on activities like co-location and kick-off meetings, which may serve as means to impose relational trust. Thus, supporting Engebø et al. (2020a) and Kent and Becerik-Gerber (2010). On the other hand, our findings also indicate that the contractual trust is utilized. As one of the owners state that ”there is no need for us to trust the contractor, because we have mechanisms in place to incentivize them to achieve our goals”. Even though this does not completely coincide with AIA California Counsil (2007)'s statement, it indicates that trust can be imposed through mechanisms like incentives.

From our analysis and discussion, we conclude that trust is important and that it can have different forms. The existing theory address two different types of trust, relational and contractual. Some authors argue that trust can not be created through contractual means (Engebø et al., 2020a; Kent and Becerik-Gerber, 2010). We question this based on our findings and conclude that the two types of trust can exist side by side, but on different levels. Our findings indicate that in order to create a good project team, it is important to create relational trust between the individuals in the team. The findings also indicate that to create commitment towards the project goals, and in so trust between the participating firms, it is important to use mechanisms, such as incentives. Hence, creating contractual trust.

7.2.3 C3: Motivation and personal compatibility should be present

C3: *Motivation **and personal compatibility** is necessary to establish collaboration.*

Proposition C3 has been revised in section 6.2.3, *C3: Motivation alone is not enough to collaborate*. Because our findings show that motivation within a project team is necessary but not enough to establish communication and trust, and that personal compatibility also has to be in place to enable collaboration.

The existing theory emphasizes that motivation is a very important factor in establishing collaboration (e.g. Azhar et al. 2014) (see section 3.2.3). The theory states that the participants must have the spirit to collaborate (Durdyev et al., 2020), cooperate (Kahvandi et al., 2017) and to trust (Azhar et al., 2014). As can be seen in the analysis in section 6.2.3, *C3: Motivation alone is not enough to collaborate*, our findings indicate that motivation is important for establishing collaboration, thus, our findings are in line with the existing theory. Some authors argue that lack of understanding and awareness of the CPDS elements and its benefits, can lead to a lack of motivation (e.g. Kahvandi et al., 2019). However, our findings indicate that this is not the case, as our informants mention that people are best motivated in the start of the projects and that they are eager to learn the new way of working. They also tell that the motivation is typically decreasing when the

design phase ends and the co-location ceases. In addition, some authors also mention briefly that personal compatibility can be a factor. Ebrahimi and Dowlatabadi (2018) argue that the team members should be individual compatible. Kick-off meetings and co-location could also be an effective way to uncover if there is personal compatibility in the team, since they have to work close together (see section 6.2.3). Engebø et al. (2020a) state that in some cases it can be necessary to replace individuals in the team, although they do not perceive this as a beneficial solution. Our findings indicate that personal compatibility is an very important factor. The informants emphasize personal compatibility within the team and tell that people were replaced due to lack of it. They are also saying that the project team improved after these replacements. Thus, our case study indicates that more focus should be directed towards personal compatibility in the existing CPDS theory.

From the previous paragraph, we see that there exist two perspectives. The first one is stating that the participants should have the spirit to collaborate, while the other one states that the participants should be compatible on a personal level. Based on our findings and discussion, we acknowledge that both perspectives are important, but also conclude that the existing theory lack the emphasis on personal compatibility. However, one might argue that the two perspectives actually addressing the same thing, but have different solutions. We perceive that the common goal of both perspectives is to create an integrated project team. The first perspectives indicates that all participants can learn to collaborate, as long as they have the motivation to put effort in the necessary work to get it to function. The latter perspective connects the ability to collaborate more to the personal characteristics and indicates that these must fit if collaboration is to be established. Indicating that the best way to establish collaboration is to replace participants when they do not fit into the team. Based on our study, we assess that both perspective have to be present for collaboration to function.

7.3 Technology

In this sub chapter, we are discussing the theoretical implications of the propositions related to technology. This is the third main element and will therefore consider the third sub research question, *"How does the use of technology influence collaborative infrastructure projects in Norway?"*.

7.3.1 T1: Interoperability issues can be reduced by new technology or information management systems

T1 *The implementation of interoperable technology platforms enhances the communication in collaborative projects.*

In section 6.3.1, *T1: Interoperable digital platforms enhances communication*, we assessed that proposition T1 is supported as our findings indicate that the use of digital technology is important for an efficient project delivery. At the same time they indicate that there are challenges related to interoperability.

From sub chapter 3.3, *Technology*, we can see that there is an agreement amongst the researches on the enhancement of communication by the use of technology in collaborative projects (e.g. Engebø et al. 2020b). The same agreement exists amongst our informants. Thus, our findings supports the theory with regards to the importance of using digital technology. In section 3.3.1, *Interoperability*, one can read that there is a general agreement that interoperability is a major challenge when using digital technology in collaborative projects (Ghassemi and Becerik-Gerber, 2011; Roy et al., 2018; Shen et al., 2010). Our findings are in line with this, as our informants mention that there are several challenges related to interoperability and that they use an excessive amount of time to transfer data between different platforms. In relation to overcoming the challenges of interoperability there are two camps in the theory. Ghassemi and Becerik-Gerber (2011) and Becerik-Gerber and Kent (2010) argue that the problems related to interoperability are caused by a lack of technology in the industry and that there is a need for a single platform tending to the needs of all participants. Others emphasize on the use of standards and information management protocols in order to overcome the challenges associated with interoperability (Azhar et al., 2014; Roy et al., 2018; Durdyev et al., 2020). Our empirical findings gives arguments for both camps. The informants state that they use several different platforms, because a platform that handle the needs of all disciplines does not exist. Furthermore, they argue that the creation of such a platform would solve the challenges related to interoperability. Other informants argue that the most efficient way to overcome the challenges is through the implementation of industry standards or information management protocols, as this can ensure that the participants only use platforms that work together and where information from one platform can easily be integrated into another.

Based on our discussion and analysis, we support that interoperability is a major challenge related to the use of technology in collaborative projects. Furthermore, we acknowledge that there are several ways of solving these challenges. However, we asses the measures discussed in the previous paragraph to be on different

levels. Creating new industry standards or a single information platform that are able to handle the needs of all participants is a measure that lies way above the project level. There are large costs related to such measures and it is not very plausible to achieve this within the scope of a single infrastructure project. Still, we might see this happen if software companies find that such development will give them a competitive advantage, or if the large actors in the infrastructure industry implement the measures into their long term strategy. Implementing information management systems and project specific technology standards is less resource demanding and can easily be done within the scope of the individual projects. This can lead to less problems with interoperability if done properly, and in so contributing to a more efficient project delivery. However, it might not contribute to solve the underlying issues.

7.3.2 T2: Both training and procedures are important in order to harvest the benefits of technology.

> T2 *Training within the chosen 3D modelling platforms is the most important factor in order to utilize the full potential of technology in a CPDS.*

In section 6.3.2, *T2: Communication is key when using 3D modelling platforms in Collaborative Projects*, we assessed proposition T2 to be unsupported because our informants emphasize more on handling revisions and procedures than on training.

From section 3.3.2, *Inexperience*, we can see that several authors state that there are challenges related to inexperience and lack of acceptance of technology within projects (Becerik-Gerber and Kent, 2010; Moreno et al., 2019; Svalestuen et al., 2017). Furthermore, we can see that there are two camps within the theory. The first camp argues that the challenges are a result of lacking skill (e.g. Ebrahimi and Dowlatabadi, 2018). From this perspective, training is important in order to overcome the challenges. In addition to training, Becerik-Gerber and Kent (2010) also argue that the challenges can be a result of an unclear collaborative framework. From this perspective, procedures seems to be the key component in successful use of digital 3D modelling tools. Our findings are most in line with the latter perspective. As the informants emphasize on lacking procedures for collaborations and communication when they address challenges related to technology. Even though the informants do not put much emphasize on it, they all mention that there has been provided training in the use of the 3D modelling platforms. They also mention that the participants are striving to learn how to utilize them. Thus, one must assume that training has been an important factor in implementing the 3D modelling technology in the case projects. Based on this discussion and our analysis, we conclude that the existing theory puts too little emphasis on creating a framework on collaborative use

of technology.

From the previous paragraph and the analysis, it seems that there is a disagreement between the existing theory and our findings with regards to the importance of training. However, we are questioning that our empirical data does not emphasize on training. One explanation for this can be that the training that was provided was successful, and thus the informants did not perceive challenges related to lack of training. One can also argue that the challenges with using the technology collaboratively is expressing that there has been lack of training in how to use technology in such a way. Consequently, the main contribution from this section is that our findings support (Becerik-Gerber and Kent, 2010) perspective, and that a collaborative framework should get more emphasis in the theory. At the same time we assess that training is an important factor as it has been provided in both case projects. Thus, we also support the other perspective. In order to address this in the ECT Framework we revise proposition E2 to:**Both training with the chosen platforms and the establishment of a collaborative framework for how to use the technology is important in a CPDS**.

7.4 Answering the Sub research questions

In this chapter we have discussed the theoretical implications of our study by the means of our propositions. We used the main elements as a structure and we created a foundation to answer the three sub research questions:

- *How does the use of ECI influence collaborative infrastructure projects in Norway?*
- *How does collaboration influence collaborative infrastructure projects in Norway?*
- *How does the use of technology influence collaborative infrastructure projects in Norway?*

In the following sections we are answering these three questions by the means of summarizing the discussions of the previous sub chapters. In addition, we are looking at our ECT framework and complement it with our answers. This creates a foundation for the answer of the main research question in the next chapter 8, *Conclusion*.

7.4.1 How does the use of ECI influence collaborative infrastructure projects in Norway?

In the sub chapter 7.1, we discuss that both the theory and our empirical findings support that ECI can improve the efficiency of a project through implementing the contractors expertise in the early phases, and in

so increasing the buildability. However we also seen that the implementation imposes several challenges into the project. In 7.1.1, we discussed that the contractor's role becomes more prominent when ECI is utilized and that this leads to an increased need for a contractor that is competent in team forming. However, even though our findings emphasize the importance of the contractor they do not disregard the importance of the owner as we can also see in section 7.1.2. Here we concluded that it is important that the owner is able to create a good project definition that describes the project deliverables, but at the same time provides the contractor with freedom to improve the project. This freedom for the contractor means that they have to take on this new role. This shows that the participants need to take on different roles. We discussed that the theory and our findings agree on the necessity of restructuring of the roles due to ECI (see 7.1.3). E.g. the designers have to engage consider the buildability of their designs and the contractors have to manage the design process as well as including their expertise in the design. Our informants underlines that this shift in roles can be ch alleging. To overcome our study suggests to use an external facilitator that has extensive experience from the AEC industry (see section 7.1.4).

Based on this our answer to the sub research question is: *ECI leads to a more holistic project delivery. This requires a competent contractor that can manage the project and the other participants. In order for this to be successful, the owner needs to provide the contractor with both specification and freedom for improvement of the project. This means the traditional roles need restructuring. To ease the process of transitioning to a CPDS, and thus utilizing ECI, a project can use an external facilitator with extensive experience from the AEC industry.*

7.4.2 How does collaboration influence collaborative infrastructure projects in Norway?

There is a need for a higher level of collaboration in a CPDS due to ECI and the interdisciplinary nature of a infrastructure project (see sub ch. 3.2). Therefore, the project team has to emphasize more on open communication, trust, motivation and personal compatibility. The existing theory suggest various means, such as kick-off meetings and co-location, to stimulate collaboration. Our study acknowledges these means. However, our study indicated that a holistic implementation of all means is superior to individual use, especially when it comes down to open communication within the project (see section 7.2.1). Our study also indicates that these means can be a good way of establishing relational trust within the project team. It also indicates that contractual trust is necessary, which can be established through incentives (see section 7.2.2). We also found that motivation and personal compatibility have to be present in order to establish collaboration. Our findings show that motivation is increased when the participants need to learn the new way of working.

This is not in line with the existing theory, which state that participants need to understand and be aware of the CPDS elements to be motivated. Nevertheless, we find motivation to be important to establish collaboration. Although, even when the participants are motivated, they might not be able to collaborate when personal compatibility is missing. Our study indicates that personal compatibility is a factor that should be emphasized in a project team, as the informants mention that members were replaced due to the lack of it. The existing theory only mentions this briefly. Thus, we asses that more focus should be directed towards personal compatibility in the CPDS theory (see section 7.2.3). We also find that the collaboration can be enhanced by technology. This will be addressed in the next section.

Based on this, our answer to the sub research question is as follow: *the level of collaboration required for a CPDS leads to a need for open communication, trust, motivation, and personal compatibility. To establish this, projects should utilize multiple collaboration enhancing measures, like kick-off meetings, co-location, communication protocols and technology.*

7.4.3 How does the use of technology influence collaborative infrastructure projects in Norway?

The technology used in a CPDS, for example 3D models or communication platforms, can enhance collaboration. It can visualize the project in a better way as well as it makes the project and the communication accessible for everyone (see ch. 3.3). However, introducing new technology also induces new challenges which are related to interoperability and inexperience. To integrate technology within a project, the technology used by the participants should be interoperable, only then all participants can access it without information loss or the need for translation (see section 7.3.1). Interoperability can be achieved by specifying which platforms to use or by creating one single information platform that covers all needs (see section 7.3.1). In addition, our discussion concludes that both training with the selected technology platforms and the creation of a collaborative framework are important to harvest the benefits of the technology (see section 7.3.2). A collaborative framework should define the expected use of the technology and it should include the communication protocol as explained in section 7.4.2, *How does collaboration influence collaborative infrastructure projects in Norway?*.

Based on this our answer to the research question is: *the use of technology can enhance collaboration in a CPDS. However, to achieve this it is required that the technology is interoperable. In addition, the creation of a collaborative framework and the provision of training with the selected platforms are necessary.*

7.4.4 Complementing the ECT framework

In the previous sections, we have answered our sub research questions. This enables us to update the ECT Framework with our answers. The updated framework is visualized in figure 8, *The ECT framework with answers to the sub research questions*.

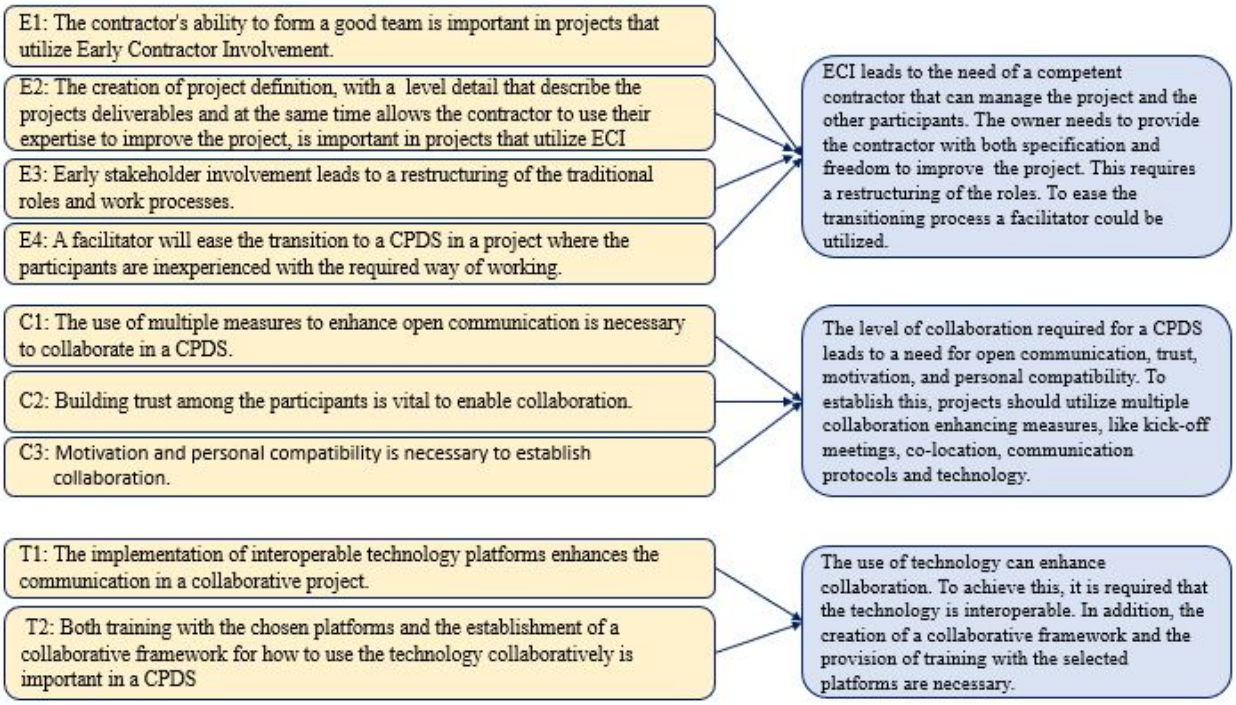


Figure 8: The ECT framework with answers to the sub research questions

This framework gives us the opportunity to answer our main research question as a conclusion of our thesis. We are providing our answer in the next chapter.

8 Conclusion

In this thesis we conducted a qualitative case study in order to answer the our research question:

> *"How can Norwegian infrastructure projects overcome the challenges related to collaborative project delivery?"*

Based on our research and the answers to the sub research questions (see. 7.4), we arrive at the following answer to the main research question. The rationale behind this answer is elaborated in 8.1, *Sustaining the conclusion*

> *In order to overcome the challenges of CPDS a holistic implementation of ECI, Collaboration and Technology is required. It is necessary in a CPDS that a good team is formed, with participants who are competent, personal compatible, collaborative and flexible to change roles. The projects needs to adopt collaboration enhancing activities, utilize interoperable technology, and define a collaborative framework in order to achieve a high level of collaboration and proper utilization of the technology.*

This answer is the last part of the ECT framework and allows us to complete it, visualized in 9, *The ECT framework with answer to the research question*. The complete framework can be seen in appendix E, *The ECT framework*.

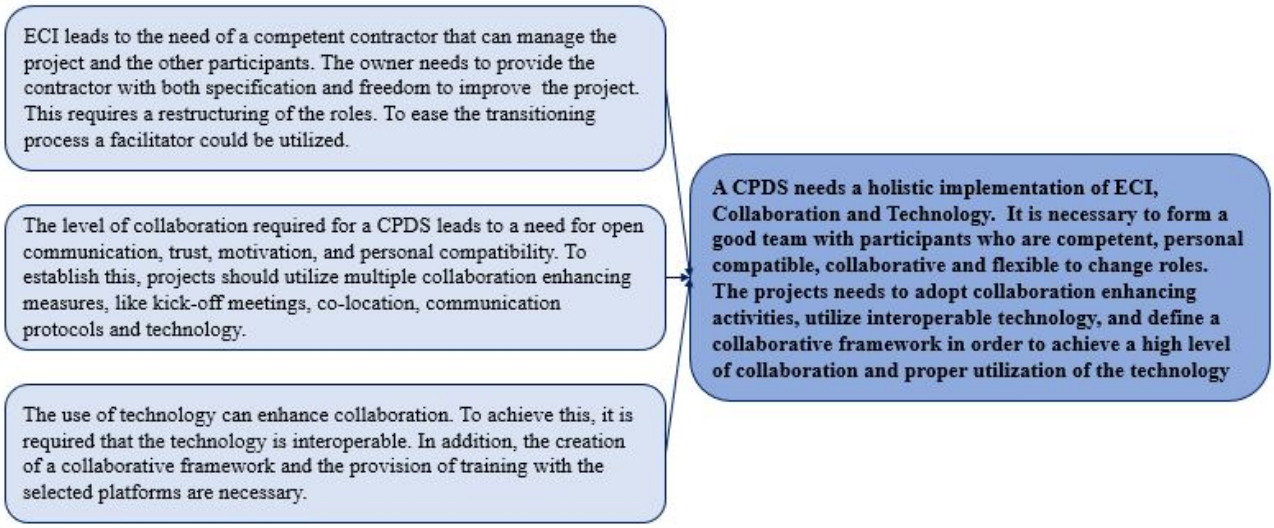


Figure 9: The ECT framework with answer to the research question

In the next sub chapter, we are elaborating the rationale behind our answer. In the subsequent sub chapters, we are discussing the theoretical contribution of our thesis, the practical implications, limitations and

opportunities for further research, before we end with a concluding remark.

8.1 Sustaining the conclusion

In our conclusion we stated that Norwegian infrastructure projects can overcome the challenges related to collaborative project delivery through a holistic implementation of the ECT framework. In this sub chapter, we are explaining how we arrived at this conclusion.

Collaboration is part of the essence of CPDS. It is a broad term and based on our challenge review (see table 2), we divided this into communication, trust, motivation. All of these aspects have to be present to create a collaborative environment (see sub ch. 7.2), however our findings show that there is a fourth aspect that has to be present, personal compatibility . In order to establish collaboration, we found that projects should use kick-off meetings (Engebø et al., 2020b), co-location (Alves and Shah, 2018) and communication protocols (AIA California Counsil, 2007).

Both the literature and our findings emphasizes that in order to establish this collaboration and to avoid fragmentation, the project team should be established early (Kent and Becerik-Gerber, 2010). Thus, ECI is important in order to establish collaboration. It is also indicated that ECI is beneficial for projects, as this allows the project to leverage the common knowledge pool and maximise the value creation (Aapaoja et al., 2013; Engebø et al., 2020b). This creates a more holistic project and a more efficient project, by avoiding rework due to insufficient project design. However, ECI introduces a set of new challenges, these are related to team forming, project definition and role restructuring (see sub chapter 3.1). To overcome these challenges, our study emphasizes the importance of selecting a competent contractor and the creation as well as the communication of a good project definition. Furthermore, our study suggests that the use of a facilitator can ease the process of transitioning to CPDS(see sub ch. 7.1).

Our study also indicates that technology can enhance the collaboration and communication between the participants (Engebø et al., 2020b; Kapogiannis and Sherratt, 2018). Hence, it is perceived as an important tool to succeed with collaboration and ECI. To harvest the intended benefits of the technology, our study indicates that the utilized technology platforms need to be interoperable (see sub ch. 7.3). Furthermore, we found that it is common to experience problems with using technology collaboratively. Consequently, it important to establish a collaborative framework for the use of technology (see sub ch. 7.2 and 7.3).

The arguments presented in this sub chapter is the basis for the answer in chapter 8,*Conclusion*, and as one can see the three elements of the ECT Framework are intertwined. Thus, in order to succeed with CPDS all three elements should be addressed within the project.

8.2 Theoretical Contribution

In this sub chapter, we are highlighting the two most important theoretical contributions of this thesis. These are the definition of a CPDS and the ECT framework.

When conducting our literature review, we noticed that most researchers address specific PDSs, like IPD, Alliancing, etc. Thus, the existing theory lacks a good definition for CPDS as a concept. Therefore, based on a comparison of these systems (see sub ch. 2.4), we formulated the following definition: *"A project delivery system that aims to improve the efficiency of projects through early contractor involvement, collaboration between participants and utilizing technology to enhance communication and collaboration. They may utilize specialized contracts, but can also exist within existing standards of local procurement laws"*. The intention of the definition was to create a foundation for our research. However, we find that the definition is in it self a contribution to the theory as it creates a good starting point for discussing CPDS as a concept.

The ECT framework is the main contribution of our research. It indicates which areas to focus on when setting up collaborative projects. In addition, it adds to the theory in three areas. The first finding is that the existing theory emphasizes too much on the owner's role and neglects the contractor's role. The second finding is that collaboration can be established by holistic use of various measures, which deviates from the existing theory which focuses on individual implementation of the measures. The third and last finding is that the theory has an extensive focus on training with technology, whereas we found that the establishment of a framework on how to use the technology collaborative is equally important. In the next sub chapter, we are examining the practical implications of our findings.

8.3 Practical implications

Throughout this thesis we examined the challenges related to CPDS and how to overcome these challenges. In this, chapter we are suggesting how to ease the process of setting up a collaborative project based on the findings from our research. The sub chapter gives recommendations on each of the three main elements of the ECT framework.

Our findings indicate that having a competent contractor is very important when setting up a collaborative infrastructure project. Thus, we recommend that great care is taken in the process of procuring a contractor. There are several ways of achieving this. One way to achieve this, can be to use Best Value Procurement as our case projects did. However, a thorough examination of procurement methods is beyond the scope of these thesis. Nevertheless, other methods may also be suitable. The benefits of using CPDS lies in utilizing the combined expertise of both designers and contractors from the early phases of the project. However, to harvest these benefits both risk and mandate have to be transferred from the owner to the contractor. In order to do this and at the same time ensure that the end product withholds the intended quality, owners should create a resilient project definition that provides both freedom to improve the project and at the same time defines the quality of the deliverables. When the procurement process is finished and a good project definition is in place the next step is to set up the project team. Our findings indicate that there is a need to restructure the traditional roles, when engaging in collaborative projects. To ease the process of transitioning to CPDS, we recommend that the contractors engage an external facilitator that has extensive experience from the AEC industry and with collaborative projects.

With regards to establishing collaboration, we found that it is key to establish communication and trust within the project team early in the project. Our findings indicate that the best way to do this is through combining kick-off meetings, co-location and the use of a communication protocol. However, for this to work the team members must be motivated to work with each other. Thus, we recommend that organizations select people that are eager to explore this new way of working. We also recommend that the participants are prepared to replace people if necessary, as our findings indicate that lack of personal compatibility can harm the teamwork. On the company level the situation is a bit different, our findings indicate that the participants will strive to maximize their own bottom line. Trust at this levels must be established through incentives and disincentives rather than through relations. To establish trust between the organizational participants, we recommend that the owners include incentives that links the interest of the participants with the interest of the project in the project definition.

The final issue we are addressing with our recommendations is technology. Both the theory and our empirical data describe that the use of technology has a huge possibility to improve the efficiency of projects. However, it can also create a set of challenges. The most prominent challenge is related to the use of interoperable platforms. To avoid this challenge on a project level, we recommend that the contractor create

guidelines on which platforms to use, early in the process, to ensure that the designers and subcontractors use the same platforms. On a strategic level, we suggest that companies engage and invest in the creation of industry standards, as we perceive that this is the only way to overcome the interoperability challenge once and for all. Even if one manage to solve the interoperability issue, it is likely that projects will encounter problems related to the use of technology. We found that there is a need for both training and procedures on how use the technology collaboratively. Based on this we recommend that both companies and projects provide both basic training with the relevant platforms and training in how to use the platforms collaboratively.

8.4 Limitations

This thesis is subject to a set of limitations to the research. In this sub chapter we are addressing the most prominent limitations.

The first limitation is related to the scope of the thesis and the initial literature review. The review is limited to publications related to collaborative PDS's, because our research question aims towards an overall view on the challenges related to such systems. We also chose to exclude issues related to contracts. However, it is clear to us that there are issues related to contracts in the different types of CPDSs. These issues are often heavily related to specific characteristics of the different projects and the local laws and regulations. Thus, including these issues would have made our research less transferable. The review could also have been broadened if we had chosen to include an extensive review of each of the three main issues, ECI, Collaboration and Technology. This could have given valuable insights on some topics, but it would dilute the overall view and would likely have resulted in an unmanageable amount of publications that would have to be reviewed. Making these choices increased the transferable of our research as we emphasise on general challenges rather than challenges that are context specific. It has also allowed us to maintain a holistic perspective and to connect the three main issues to CPDS through the ECT framework.

A second limitation is related to the data collection. Our findings are based on data collection from two Public Norwegian Infrastructure Projects. Certain findings can be related to this specific context. Thus, one might question whether the findings are transferable to other contexts. Still, as mentioned in the previous paragraph, our research mainly concerns issues that are disconnected from factors like local laws and regulations. Thus, we assess that it is likely that many of the findings are relevant for other context. Furthermore, our data collection is entirely based on interview material which can lead to the risk that the material is

subject to biases that exist within the case projects or the industry. However, we aimed to counter this by carefully selecting informants in different positions and within the different participating companies (see section 4.2.5). On the other hand, this strategy allowed us to highlight the perspectives of the industry practitioners and evaluate the existing theory in the light of this perspective.

A third limitation is the potential for personal bias. When we started to work on this thesis, we had a very positive view on CPDS and its potential to transform the infrastructure industry. We strived to stay objective. However, our impression of the topic is likely to have influenced our interpretations. E.g. researchers with different perspectives on CPDS might have conducted the interviews differently and interpreted the data in another way. Still, it is not likely that this have influenced our conclusions and findings in any substantial way, as our research question does not aim towards uncovering whether CPDS is superior to other PDS. In addition, we used several measures to ensure that our personal inclinations did not influence our interpretations or conclusions (see section 4.3.1).

8.5 Further research

In our study we identified three areas that would be interesting for further research. The fist one is if and how the use of a facilitator can ease the process of setting up a CPDS. Our research addressed this topic, but due to a scare data foundation on the area, we were not able to conclude. Hence, there is uncertainty attached to the ECT framework. Thus, more research on this field is needed to strengthen the ECT framework and to give insights on how to use a facilitator to improve the transitioning to a CPDS. This could be done by performing a qualitative comparative case study where one compares projects that use a facilitator and projects that do not use a facilitator.

The second area is related to conducting a similar research in other contexts or cultures. This thesis is based on two Norwegian Infrastructure Projects. Therefore, some of the findings might be specific to this context. To establish whether the findings in this thesis and the ECT framework are applicable in other settings, we suggest to examine collaborative projects in other contexts. For example, a study on collaborative projects in the building industry. It could also be achieved by performing a similar study in other countries, e.g. other Scandinavian countries.

Finally, an increasing amount of Norwegian Infrastructure projects are being conducted as collaborative projects. However, there is little evidence showing whether the use of CPDS is more efficient than TPDS in

the Norwegian Infrastructure Industry. Thus, we suggest that a quantitative study, where the results of collaborative and traditional projects are compared, is performed. However, in order to achieve this, one must wait until the amount of finished collaborative projects is high enough to form a sufficient sample size.

8.6 Concluding remark

This thesis indicates that Collaborative Project Delivery is a concept that comprises of several different delivery systems. These systems share emphasis on Early Contractor Involvement, Collaboration and Technology. There are three major findings from our research. The first finding is that the existing theory emphasizes too much on the owner's role and neglects the contractor's role. The second finding is that the theory have an extensive focus on training with technology, whereas we found that the establishment of a framework on how to use the technology collaboratively is equally important. Our last main finding is that collaboration can be established by the holistic use of various collaboration enhancing measures, which deviates from the existing theory which focuses on individual implementation of these measures. The conclusion of our study is that in order to overcome the challenges of collaborative project delivery, a holistic implementation of the ECT framework is necessary.

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Appendix

A Challenges

Category	Subcategory	Challenges	Sources
Early Stakeholder Involvement	General	Cost early in project	Engebø et al. (2020b)
		High initial investment and risk	Durdyev et al. (2020)
		Cost/benefit ratio	Rahmani (2020)
		Unfamiliarity of ECI	Rahmani (2020)
	Team Forming	Finding capable and committed participants	Aapaoja et al. (2013)
		Competent owner with expertise in team formation and team building	AIA California Counsil (2014)
		Loss and replacement of participants	AIA California Counsil (2014)
		Early team formation	Becerik-Gerber and Kent (2010)
		Replacement of project leader	Butt et al. (2016)
		Inexperienced participants with IPD	Ebrahimi and Dowlatabadi (2018)
		Selecting the right team	Ebrahimi and Dowlatabadi (2018)
		Owner needs to find a team with autonomy and authority	Engebø et al. (2020b)
		Replacing participants	Engebø et al. (2020b)
		Bringing members late in the process	Ghassemi and Becerik-Gerber (2011)
		Lack of knowledge within team	Ghassemi and Becerik-Gerber (2011)
		Selecting right team early and based on quality instead of costs	Ghassemi and Becerik-Gerber (2011)
		Unable to select right team	Ghassemi and Becerik-Gerber (2011)
		Lack of integration within team	Rahman and Alhassan (2012)
		Competent and risk tolerant owner	Roy et al. (2018)
		Inexperience with participants and IPD	Roy et al. (2018)
		Involvement of subcontractors	Roy et al. (2018)
	Project Definition	Misunderstood perspective of the project value among participants	Aapaoja et al. (2013)
		Need to merge different needs and objectives for an effective delivery process	Aapaoja et al. (2013)
		Early definition of project goals	Becerik-Gerber and Kent (2010)
		Unclear decision making process	Butt et al. (2016)
		Unclear or late decisions made by owner	Durdyev et al. (2020)
		Breaking down individual silos and set clear lines of responsibility	Ebrahimi and Dowlatabadi (2018)
		Making sound and timely decisions	Ebrahimi and Dowlatabadi (2018)
		Understanding IPD, roles and responsibilities	Ebrahimi and Dowlatabadi (2018)
		Shared decision making creates unclear authority	Engebø et al. (2020b)
		Inexperience with the process	Fish and Keen (2012)
		Owner need to provide project goals in terms of scope, quality expectations, budget, schedule and planning the project	Ghassemi and Becerik-Gerber (2011)
		Perceived project content and customer requirements	Hoezen (2012)
		Unclear allocation of responsibilities	Rahman and Alhassan (2012)
		Early definition of target goals	Roy et al. (2018)
	Role Restructuring	Need for facilitation from team selection stage through all other phases	Abdirad and Dossick (2019)
		Relationships and work processes need to change	Azhar et al. (2014)
		Role restructuring required mind shift from traditional way of working	Azhar et al. (2014)
		Changing participants roles	Ebrahimi and Dowlatabadi (2018)
		Willing and able to be a facilitator	Fish and Keen (2012)
		IPD not designed to include a facilitator	Ghassemi and Becerik-Gerber (2011)
		Change in relationship protocol and change in roles	Rahmani (2020)
		Unable to accept or adapt to new roles	Whang et al. (2019)
Collaboration	Communication	Co-location is not realistic for everyone	Aapaoja et al. (2013)
		Lack of IT infrastructure support	Azhar et al. (2014)
		Lack of information	Butt et al. (2016)
		Overflow of information	Butt et al. (2016)
		Lack of collaboration and communication	Durdyev et al. (2020)
		Poor relationships between participants	Durdyev et al. (2020)
		Lack of continuous, open and honest communication	Rahman and Alhassan (2012)
		Lack of integration in digital platforms	Shen et al. (2010)

Table 5: Full challenge review part 1

Category	Subcategory	Challenges	Sources
Collaboration	Trust	Building trust takes time	Aapaoja et al. (2013)
		Developing a high level of trust	Andary et al. (2019)
		Work to own interest	Alves and Shah (2018)
		Poor relationships between participants	Durdyev et al. (2020)
		Lack of trust	Engebø et al. (2020a)
		IPD can not function without trust	Fish and Keen (2012)
		Mutual trust and respect	Ghassemi and Becerik-Gerber (2011)
		Trust is important for project success	Ilozor and Kelly (2012)
		Teamwork and mutual trust are important	Kahvandi et al. (2017)
		Lack of trust	Rahman and Alhassan (2012)
		Mutual trust and respect	Roy et al. (2018)
		Inexperience with other participants affects trust	Sun et al. (2015)
	Motivation	Unsuitable players for working in an IPD	Aapaoja et al. (2013)
		Lack of commitment to mutual objectives and incentives	Aapaoja et al. (2013)
		Lack of willingness to change habits	Aapaoja et al. (2013)
		Unawareness of IPD process, incentives and participants impact	Aapaoja et al. (2013)
		No incentives to collaborate with others	Alves and Shah (2018)
		Willingness and knowledge of owner to take lead in IPD	Azhar et al. (2014)
		Willingness to collaborate and trust	Azhar et al. (2014)
		Lack of involvement of owner or contractor	Durdyev et al. (2020)
		Lack of spirit to collaborate	Durdyev et al. (2020)
		Unwilling to vary from traditional methods	Durdyev et al. (2020)
		Acceptance and willingness to embed IPD concepts	Ebrahimi and Dowlatabadi (2018)
		Individual members personalities need to fit together	Ebrahimi and Dowlatabadi (2018)
		Traditional adversarial mentality	Ebrahimi and Dowlatabadi (2018)
		Support and commitment of top management	Engebø et al. (2020b)
		Lack of understanding of implementation of IPD	Kahvandi et al. (2017)
		Fear of change in the industry	Kent and Becerik-Gerber (2010)
		Lack of IPD awareness	Kent and Becerik-Gerber (2010)
		Lack of IPD understanding of the owner	Kent and Becerik-Gerber (2010)
		Monetary incentives are not enough	Kent and Becerik-Gerber (2010)
		Lack of willingness to collaborate	Rahman and Alhassan (2012)
		Participants are focused on their own incentives	Rahman and Alhassan (2012)
		Traditional mindset	Rahmani (2020)
		Awareness and willingness to implement IPD concepts	Roy et al. (2018)
Technology	Interoperability	Each participant utilizes their own IT system based on their needs and availability	Azhar et al. (2014)
		Lack of information management protocols	Azhar et al. (2014)
		Technology and BIM are not advance enough for IPD	Becerik-Gerber and Kent (2010)
		Lack of utilization of BIM	Durdyev et al. (2020)
		Only partial integration achieved	Ebrahimi and Dowlatabadi (2018)
		Lack of interoperability	Ghassemi and Becerik-Gerber (2011)
		Lack of technology	Ghassemi and Becerik-Gerber (2011)
		Integration of information and systems	Roy et al. (2018)
		Unclear BIM standards	Roy et al. (2018)
		Lack of system integration	Shen et al. (2010)
	Inexperience	Inexperience with BIM and no training in BIM	Becerik-Gerber and Kent (2010)
		Lack of standard BIM contract	Becerik-Gerber and Kent (2010)
		Lack of a collaborative framework	Becerik-Gerber and Kent (2010)
		Expensive to provide BIM training	Ebrahimi and Dowlatabadi (2018)
		Lack of understanding the software	Kapogiannis and Sherratt (2018)
		Cost of BIM and training	Moreno et al. (2019)
		Lack of expertise in technology	Moreno et al. (2019)
		Lack of technical knowledge of owner	Rahman and Alhassan (2012)
		Cost/benefit ratio of technology	Svalestuen et al. (2017)
		Lack of motivation, trust and poor usability of the systems	Svalestuen et al. (2017)

Table 6: Full challange review part 2

B Interview guide

Interview guide.

Introduction.

We are writing our master thesis on Collaborative Project Delivery Systems in the Norwegian construction industry and what is necessary to create a more efficient project. Therefore, we would like to ask you some questions related to the infrastructure project ……

We would first like to start with some personal background information.

1. **Background information** (*This part will not be included in the sound file and the answers will be stored separately.*)
    a. Which actor are you representing? (Project owner/design firm/contractor)
    b. What is your position in the project?
    c. What is your educational background?

As mentioned in the statement of consent we wish to record the audio from the interview. It will be stored separate from your personal information and will be transcribed as soon as possible. It will not be possible to identify you personal from the results. We would therefore ask you if it is ok that we start the recording now?

    d. How long have you worked within the construction industry?
    e. How long have you worked with infrastructure projects?

Like we just said, we are looking into collaborative project delivery systems. And especially the challenges related to these projects. To get an overview on how this project is different from traditional projects, we would like to know more about your view on traditional projects.

2) **Normal Project**
    a. **How would you describe a Traditional infrastructure project in the Norwegian Industry?**
        - **PDS / contract form**
        - **Involvement of the stakeholders**
        - **Amount of Collaboration**
        - **Use of Technology**

As you know we are here to study the …… project. We would like to ask more about that project.

3) **Characterization of the project**
    a. **How would you characterise this project?**
        i. When did the participants get involved during the project?
        ii. Were the participants familiar with each other?
        iii. How would you describe the level of collaboration, think about communication/trust/motivation, between the different participants?
        iv. How was the communication between the participants?
        v. What kind of technology is used in the Project?
    b. **So what do you think is different in this project compared to a classic project?**
        i. Involvement of participants?

ii. Collaboration between the participants – communication?
iii. Use in Technology?

We are also curious about the challenges that occurred during the project and mainly/specifically the challenges that you have perceived/experienced, so we would like to talk about that.

4) **Challenges of the project**
   a. **In your experience what were/are the main challenges during this project?**
      i. Were there any challenges related to the early involvement of the contractor (Involving of the project participants in the early phases).
         - Team Forming?
         - Role restructuring? (compared to other projects)
      ii. Were there any challenges related to collaboration?
         - Trust
         - Communication
         - Motivation (monetary)

           Do you feel you managed to build mutual trust/motivation in the project team ?
      iii. Were there any disputes in the project?
         - How did you solve them?
      iv. Were there any challenges related to the use of technology?
         - BIM
         - Integration/ interoperability
         - Inexperience
   b. **In your experience how did the project team overcome these challenges? (Will be used as a follow up during the whole of part three.)**
   c. **Is there anything else that you think has influenced the project in particular?**

We are also interested in connections between the challenges. The literature is mentioning challenges related to the concepts Early contractor involvement, collaboration and technology, especially BIM. (if applicable: challenges you have also mentioned, or: however, you have also mentioned other challenges, related to other concepts)

5) **Linking the concepts**
   a. **Do you think certain challenges were/are related to each other or influenced by each other?**
      i. Do you perceive that the concepts BIM, Collaboration and Early Contractor Involvement are influencing one another during the project?
         - What influences what?
         - How?

As well would we like to ask if there ....

6) **Learning moments**
   a. **Are there any aspects from this project you would like to bring into the next project?**

b. **Are there any aspects you would like to do different in next projects?**

7) **Perceived Success**
   a. **Do you think it is/was possible for your firm to achieve success without the project being successful?**
   b. **Can you elaborate this?**

8) **Is there anything else you would like to add?**

Thank you for your time and your answers. Would it be possible to contact you again if we find new things and would need more information to complete our research?

C NSD approval

NSD NORSK SENTER FOR FORSKNINGSDATA

NSD sin vurdering

Prosjekttittel

Masteroppgave Integrated Project Delivery

Referansenummer

965235

Registrert

08.01.2021 av Torstein Hellebust - torsthel@stud.ntnu.no

Behandlingsansvarlig institusjon

Norges teknisk-naturvitenskapelige universitet / Fakultet for økonomi (ØK) / Institutt for industriell økonomi og teknologiledelse

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)

Ola Edvin Vie, ola.edvin.vie@iot.ntnu.no, tlf: 73596340

Type prosjekt

Studentprosjekt, masterstudium

Kontaktinformasjon, student

Torstein Hellebust , Torsthel@stud.ntnu.no , tlf: 90787286

Prosjektperiode

14.01.2021 - 20.06.2021

Status

09.02.2021 - Vurdert

Vurdering (1)

09.02.2021 - Vurdert

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet med vedlegg den 09.02.2021, samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilke type endringer det er nødvendig å melde:

https://www.nsd.no/personverntjenester/fylle-ut-meldeskjema-for-personopplysninger/melde-endringer-i-meldeskjema

Du må vente på svar fra NSD før endringen gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til 20.06.2021.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake.

Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER
NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

• lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
• formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke behandles til nye, uforenlige formål
• dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
• lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), og dataportabilitet (art. 20).

NSD vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og/eller rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til med prosjektet!

Tlf. Personverntjenester: 55 58 21 17 (tast 1)

D Form of consent

Vil du delta i forskningsprosjektet

"Collaborative project delivery in the Norwegian construction industry."?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å undersøke hvilke utfordringer som oppstår i forbindelse med infrastrukturprosjekter hvor graden av samspill mellom aktørene er høy. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål
Formålet med denne masteroppgaven er å utvikle teori relatert til "samarbeidende prosjektledelse". Dette vil bli gjort gjennom å undersøke hvilke utfordringer som oppstår når graden av samspill er høy i infrastrukturprosjekter. Videre søker oppgaven også å undersøke hvordan utfordringene bør håndteres. Det overordnede forskningsspørsmålet for oppgaven er: Hvordan kan Norske infrastrukturprosjekter løse utfordringene som er knyttet til "Collaborative Project Delivery" (Samarbeidende prosjektleveranser)?

For å besvare dette spørsmålet vil vi kartlegge hvilke utfordringer som er identifisert i bygge bransjen, og undersøke hvordan disse har blitt løst. Deretter vil vi sammenligne dette med relevant teori. Resultatet vil lede til ny teori eller teoriendringer for effektivt samspill i infrastruktur prosjekter.

Hvem er ansvarlig for forskningsprosjektet?
Institutt for industriell økonomi og teknologiledelse ved NTNU er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
I samarbeid med kontaktpersoner i prosjektene E6 Arnkvern-Moelv eller Mandal Øst-Mandal By er du blant et titalls personer utvalgt til å delta i forskningsprosjektet. Da du har arbeidet på ett av prosjektene, og dermed har kunnskap om prosjektenes gjennomføring og kan belyse interessante problemstillinger relatert til denne.

Hva innebærer det for deg å delta?
Hvis du velger å delta i prosjektet, innebærer det at du deltar på et intervju som vil vare i ca 1 time. Spørsmål som vil bli stilt i intervjuet er relatert til hvordan du opplevde gjennomføringen av det aktuelle prosjektet, og hvilke utfordringer som oppstod.
Ved samtykke vil det bli gjort et midlertidig lydopptak av intervjuet. Dette opptaket vil transkriberes og anonymiseres. Det gjøres oppmerksom på at identifiserende opplysninger som stilling, alder, kjønn ol. Ikke vil bli inkludert i lydfilen.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

Intervjuer som blir gjennomført vil bli anonymisert ved hjelp av koder under transkribering. Disse

kodene vil erstatte identifiserbare opplysninger som navn, alder etc. og bli oppbevart adskilt fra øvrige data. Kun de to gjennomførende masterstudentene og deres veileder vil få tilgang på datamaterialet. Intervjuobjektene vil også være anonymisert i oppgaveteksten og dermed ikke gjenkjennbare.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
Opplysningene transkriberes og anonymiseres så fort som mulig, og alle lydopptak og personopplysninger vil slettes når prosjektet avsluttes/oppgaven er godkjent, noe som etter planen er 11. Juni 2021.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:
- innsyn i hvilke personopplysninger som er registrert om deg, og å få utlevert en kopi av opplysningene,
- å få rettet personopplysninger om deg,
- å få slettet personopplysninger om deg, og
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger.

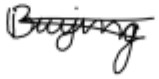
Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Institutt for industriell økonomi og teknologiledelse ved NTNU har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:
- *Institutt for industriell økonomi og teknologiledelse ved Ola Edvin Vie tlf: 73596340*
- *Vårt personvernombud: Thomas Helgesen*

Hvis du har spørsmål knyttet til NSD sin vurdering av prosjektet, kan du ta kontakt med:
- NSD – Norsk senter for forskningsdata AS på epost (personverntjenester@nsd.no) eller på telefon: 55 58 21 17.

Med vennlig hilsen


Prosjektansvarlig		
(Forsker/veileder)	(Student)	(Student)
Ola Edvin Vie	Irene Buijing	Torstein Hellebust

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet *[collaborative project delivery in the norwegian construction industry]* og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ☐ å delta i et intervju
- ☐ at det blir gjort lydopptak av intervju
- ☐

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

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(Signert av prosjektdeltaker, dato)

E The ECT framework

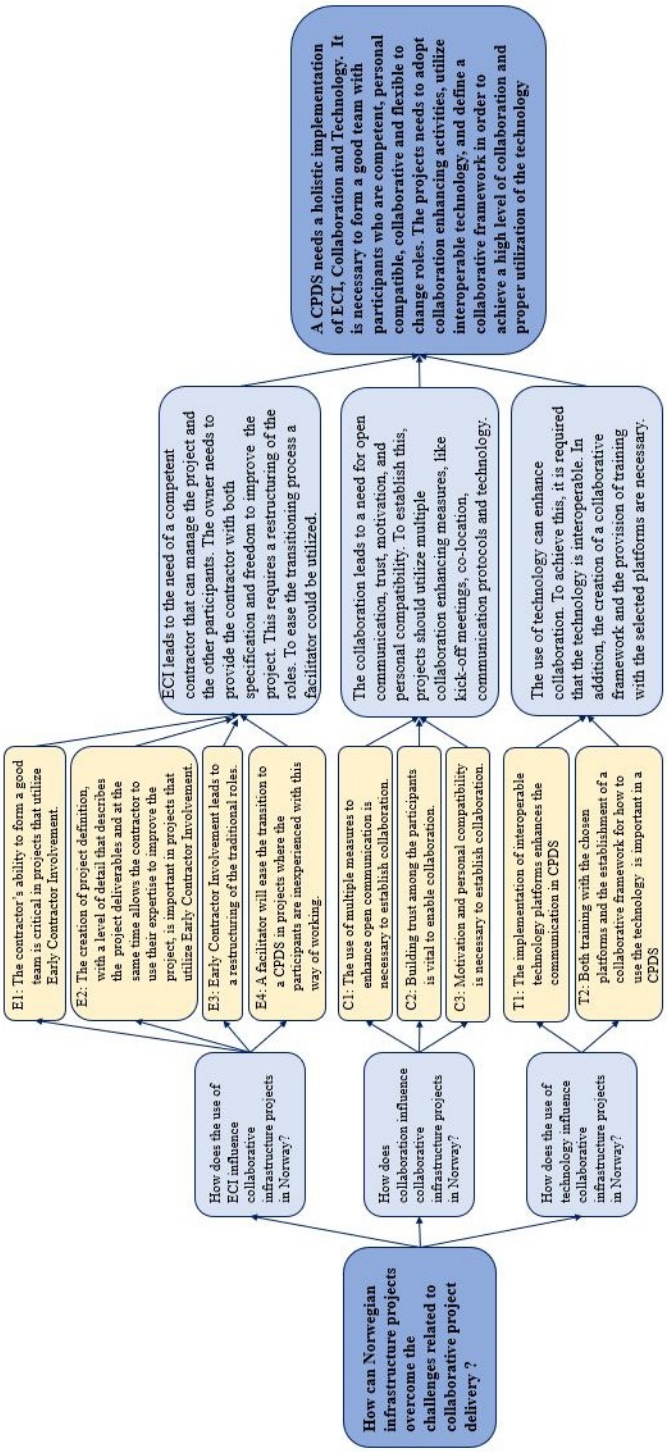

Figure 10: The ECT framework

Torstein Hellebust, Irene Klary Annelies

Enhancing CPDS in the Norwegian infrastructure industry

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