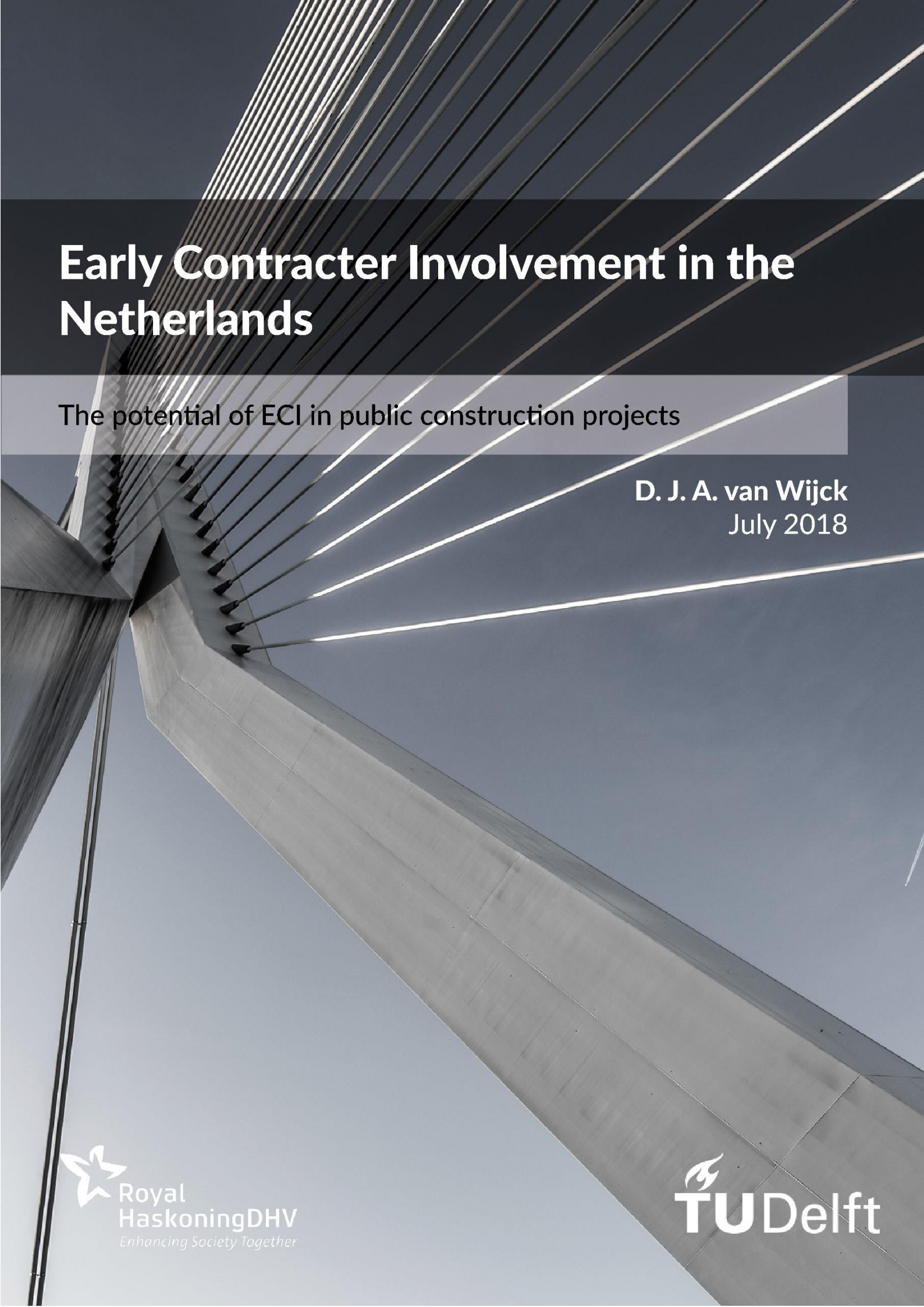


Early Contracter Involvement in the Netherlands

The potential of ECI in public construction projects

D. J. A. van Wijck

July 2018

Royal HaskoningDHV
Enhancing Society Together

TU Delft

This thesis was written in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (MSc)

in Construction Management & Engineering

At the Delft University of Technology

With special thanks to my graduation company:

Colophon

Author:	D.J.A. van Wijck
Student no.:	4008073
E-mail address:	dirkvanwijck@gmail.com

Date:	16-7-2018
Location:	Delft

Study Program:	MSc Construction Management & Engineering
Faculty:	Civil Engineering & Geosciences
University:	Delft University of Technology

Graduation Company:	Royal HaskoningDHV Business Unit Transport & Planning

Graduation Committee:

Professor:	Prof. Dr. H.L.M. Bakker
1st Supervisor:	Dr. Ir. L. Volker
2nd Supervisor:	Ir. L.P.I.M. Hombergen
Company Supervisor:	Ir. E. Korvinus

A digital version of this thesis will be available at https://repository.tudelft.nl

Preface

These last six months of researching Early Contractor Involvement have been a rollercoaster ride unprecedented in my studies. The ride has been exciting, entertaining and difficult at times, but it delivered me at the end of my studies in Delft with a resulting thesis that feels like a worthy finish of my master Construction, Management & Engineering at the Technical University of Delft. The process to get here has taught me a lot about public construction and myself.

During my time in Sweden the spark of interest in ECI ignited. As soon as I got home, everything for my thesis research was put in motion. Within a month, the subject and research proposal took shape under the supervision of my graduation committee. When the kick-off was completed, I strapped in, and started my run in the graduation rollercoaster.

Firstly, I like to thank my committee. My first supervisor, Leentje Volker, dared me to use a method very rarely used before, and whilst I was struggling with the subject or method, dared me to go even further which resulted in this thesis that I am very proud of. My second supervisor, Leon, whose bright and positive mood never wavered once. His advice, jokes and network made the process a lot better and much more fun. My company supervisor at RHDHV, Esther Korvinus, for whom I was the first graduate she supervised, always made time for me when needed. She had a keen eye and perfect understanding of what was required of me as she was a CME graduate herself recently. And I like to thank my professor, Hans Bakker, whose practical view and hands-on attitude helped to complete the rollercoaster ride in a nice and orderly fashion. The dynamics in the meetings with the committee have always been fruitful, interesting and encouraging. I could not have wished for a better committee for my graduation project.

I also want to thank my expert panel for making time for the interviews and taking the effort to fill in the questionnaires. Without them, this research would not have been possible. In addition, I would like to thank Marcel Hertogh for making the time for a confirmation session on the results. I also want to thank Tanja Helder and Sandra Schuchmann for their organizational help. Also, a word of thanks to my fellow graduate students, who have made the process so much more enjoyable with coffee, jokes, discussions and their vote of confidence in my work.

And finally, I want to give special thanks to the people close to me for putting up with the endless graduation talk and my absence during many social events. My friend Micha gave me the tips before I started that helped to make this period a success. My housemates always provided a much-appreciated outlet for the frustration that comes with graduation. This also goes for my girlfriend, her family and my own family, who supported me through the inevitable rough patches that go hand in hand with graduation work. I do not want to imagine what this period would have been like without their support.

Whilst writing this preface I realize the rollercoaster is almost at the end. As I prepare for my thesis defense, I hope you enjoy the read!

D.J.A. van Wijck
Delft, July 2018

Abstract

Public construction projects have an image of poor performance, both in the Netherlands and other countries. Too many public projects go over budget and over time. A possible improvement to this poor performance could be Early Contractor Involvement (ECI). ECI literally translates to involving a contractor “early”, which in current practice implies that the contractor is involved before the design phase. As a more unambiguous definition was missing for this principle in the Netherlands, this research identified two varieties of ECI; a consulting form (like a market consultation) or a contracting form, where the contractor is contracted during the final stages of the initiation phase. ECI is suggested in literature to be a promising option to improve public construction projects in the Netherlands, but literature is split on what ECI is and what the benefits are. This thesis study aims to identify the effects, implications and implementation of ECI in the Netherlands. From this study, eight potential benefits of ECI have been identified by means of a Delphi study. Some examples of these benefits are improved risk assessment, risk distribution, higher project quality and higher certainties in both costs and planning. However, reaping these benefits requires preparation and experiments with projects using ECI. There currently seems to be no initiatives with ECI on the agenda, except the refurbishment project of the Hoevelaken intersection.

To implement ECI in the Dutch public construction industry, this research found several conditions to implement and use ECI. Firstly, the role division of the client, design firm and contractor should be done differently. Secondly, the distribution of the risks must change. And thirdly, procurement may have to be specifically designed for ECI. In addition to these conditions, there are three barriers to overcome. These barriers are primarily concerned with the client side of the market. The client fears the early commitment to just one contractor and finds it hard to secure the competition in the market properly when ECI is used. Following these two barriers is a third; there is a lack of determination to experiment and implement ECI. To help overcome these barriers, four incentives are identified to be applied simultaneously:

- An investment from the public sector to experiment with ECI,
- Design of a proper exit-clause to terminate the contract,
- The use of Past-Performance criteria for procuring projects with ECI,
- The application of incentives on contractor behavior.

When ECI is implemented in public construction in the Netherlands, ECI will have implications on both public construction projects and the construction industry. In procurement the criteria other than price are likely to become more important, as price is unrealistic to test on so early in a project. Contractors will have to develop their advising role and expand their designing/engineering capacity. As their expertise and capabilities develop, design and engineering work is likely to flow from the design firms to the contractors. The engineering expertise of the client must expand as well, to be able to communicate on the same level as the contractors to prevent communication errors and opportunistic behavior.

This research suggests that ECI can indeed improve public projects on several aspects, but if there are too few experiments to develop and improve the concept it is unlikely to see implementation soon. As communication, perseverance and determination are key in experimenting with something new, this thesis advocates investing in ECI experiments with people who are capable and willing to try to make ECI work. Proper preparation and learning from the experiments will create forward momentum. When forward momentum is gained, ECI could be disproved to work or be proved a working innovation in the construction market, marking the next market improvement on the road to collaboration in the construction industry.

Terminology & List of Abbreviations

TERMINOLOGY

Client	Owner of a project.
Contract	Legally binding document between parties.
Contract Type	Standardized form of contract.
Contractor	Party with construction as core business.
Design Team (Bouwteam)	Procedure representing ECI in the Netherlands, where the contractor, client and designer enter a coordination agreement to design a project together. Contains a clause to terminate the agreement when no agreement in price is reached between the design and construction. See section 4.3.1 *Design Team*
Designer	Catch-all term for consultants, engineers, architects and other parties concerned with producing a design for construction. Does not include the contractor.
Early Contractor Involvement (ECI)	Principle of inviting the contractor during the planning and design phase, before construction starts.
Interweaving	Procedure based on the principle of ECI, where the contractor is taken on board during the EIA procedure. The contractor takes on an advisory role for the design, where earlier involvement means more space for innovation. See section 4.3.2 *Interweaving*
Primary Involved Parties in Construction Projects	Consists of Client, Designer and Contractor (Chao-Duivis, Koning, & Ubink, 2013)
Procurement	The process of acquiring services, works or goods of an external source according to predefined criteria. Done often by standardized procedures, in forms of competitive bidding or tendering.
Procurement Strategy	Strategic consideration of the procurement method, including desired contract type and procurement criteria.

LIST OF ABBREVIATIONS

BVP	Best Value Procurement
CDD	Critical Design Decision
D&C	Design & Construct
ECI	Early Contractor Involvement
EIA	Environmental Impact Assessment
IPM	Integral Project Management
PDC	Plan, Design & Construct
TOC	Target Outturn Cost
UAV	Uniforme Administratieve Voorwaarden
UAV-GC	Uniforme Adminsitratieve Voorwaarden – Geïntregeerde Contracten

Table of Contents

Table of Figures

Table of Tables

1. Introduction

Construction projects, and especially infrastructure projects, tend to go over budget and face delays (Flyvbjerg, Holm, & Buhl, 2002; Love, Edwards, & Irani, 2012). According to Flyvbjerg et al. (2002), this can be linked to, among other factors, optimism bias and cost underestimation. Love et al. (2012) go deeper and found that design errors may also be the cause for these cost overruns and delays. The improper division of project risk and competitive tendering on price are also factors named in literature (Koenen & van de Pol, 2015). Several sources agree that there are structural problems in large construction projects (Boes & Dorée, 2013; Bundgaard, Klazinga, & Visser, 2011; Flyvbjerg et al., 2002; Leendertse, Lenferink, & Arts, 2012; Rahman & Alhassan, 2012). As the search for a solution for the delays and cost overruns continues in the direction of cooperation and collaboration (Eriksson & Westerberg, 2011), a possible solution arises; *Early Contractor Involvement (ECI)* (van Valkenburg, Lenferink, Nijsten, & Arts, 2008). The name ECI comes from the principle of taking the contractor on board early in a construction project. This seems different to traditional project procurement in the Netherlands, where the contractor becomes involved when the construction of a design is procured (Chao-Duivis et al., 2013). There are other forms of contracting available, like framework agreements, alliances and integrated contracts (Hermans, 2017). It could be argued that ECI is a form of integrated contracts as specified in the Dutch UAV-GC (Bundgaard et al., 2011), but this is not widely recognized in literature. However, there is a new variation to integrated contracts called Plan, Design & Construct, which resembles the principle of ECI. Interweaving and Design team have also been called ECI in literature (Chao-Duivis, 2012; van Valkenburg et al., 2008). There are also foreign concepts and contracts available which could be argued to possibly contain ECI; FIDIC's Yellow Book for example, or NEC ECI clauses (Cobouw, 2010; NEC, 2016).

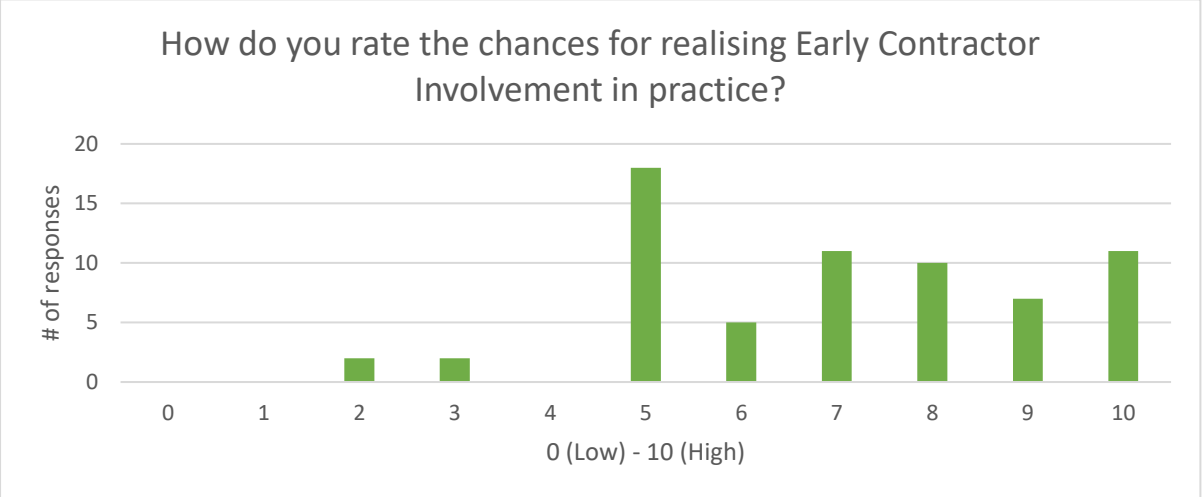


Figure 1: Results of the poll on realizing ECI in practice (reconstructed figure from Bundgaard et al, 2011).

So, what is ECI exactly? What does it improve? Leaving the definition at '*involving a contractor in the planning and design phase*' for now, let's focus on the benefits. The benefits of ECI range from higher planning and cost certainty, reductions in costs and faster project delivery to higher quality and more innovation (Scheepbouwer & Humphries, 2011; Spang, 2012). The disadvantages that are mentioned by Spang (2012) seem minor; some extra costs in the tender phase and a conflict of interest between the client and contractor in the design phase. There also seem to be risks involved with ECI, like

opportunistic behavior from the contractor and possible restrictions from EU regulation (Wondimu, Hosseini, Lohne, Hailemichael, & Lædre, 2016).

The Dutch construction sector recognizes the possibilities of ECI and seems interested in its implementation (Koenen & van de Pol, 2015). Other countries in the EU are also interested. Figure 1 shows a poll done on the international Forum on Early Contractor Involvement in London, 2011 (Bundgaard et al., 2011). This figure shows the confidence in ECI from the different experts present at the conference. The confidence that collaborative efforts are the way to improve construction projects is recognized in the Netherlands as the guidelines in the "Marktvisie" (the vision on the market) show (The Dutch Construction Sector, 2016).

As the benefits seem to outweigh the disadvantages, why is ECI not implemented yet? It is in some countries, to different degrees; the United Kingdom (UK), Australia, New Zealand and Sweden have implemented ECI procedures (Kadefors, 2017; Scheepbouwer & Humphries, 2011). There even are some standardized methodologies for ECI available for these countries, like the NEC3/NEC4 ECI clause (NEC, 2016). The need for ECI may have been higher and/or different in these countries compared to the Netherlands, but the benefits are recognized for the Netherlands and other countries as well (Bundgaard et al., 2011). There is research done already on ECI in the Netherlands, but somehow we still are not ready to implement ECI (Lenferink, Arts, Tillema, van Valkenburg, & Nijsten, 2012; van Huuksloot, 2014).

Earlier research in ECI found that literature on the definition and implementation of ECI was lacking in the Netherlands (van Huuksloot, 2014). The benefits of ECI in this thesis study are derived from the UK ECI implementation, and several projects are deemed fit for their ECI approach. Also, a lot more research is done on ECI in recent years. Research on European implementation of ECI states that the implementation of ECI in Norway could benefit construction projects there as well, also pointing at ECI in the UK (Wondimu, Hosseini, et al., 2016). Wondimu et al. (2016) however found that public bodies did not really try to implement ECI, possibly due to the EU (or other governance) directives, making implementation difficult. Others suggest that conservatism is the main problem (Love, O'Donoghue, Davis, & Smith, 2014). In the Netherlands people are optimistic on the concept of ECI, as the direction is set towards more collaboration in the construction markets (The Dutch Construction Sector, 2016). The implementation of ECI faces several barriers though. The very limited available information on ECI, the current contracting practice and especially the difficulty of achieving cultural change make the effective implementation of ECI difficult (Song, Mohamed, & AbouRizk, 2009).

The closest representations of what could be considered ECI in the Netherlands according to literature would be either a *Design Team* ("Bouwteam" in Dutch) or interweaving (Chao-Duivis et al., 2013; Lenferink et al., 2012). The design team form of contracting in construction contracts builds on the cooperation between the client, designer and contractor to help each other during the complete duration of the project. The main characteristic is that the design team is formed in equal partnership between these parties (Chao-Duivis et al., 2013). Interweaving focusses on procurement procedures parallel to the environmental impact assessment (EIA) procedures (van Valkenburg et al., 2008). This way, the contractors can contribute their expertise during the track decision for infrastructure projects (Overkleeft, 2017; van Valkenburg et al., 2008). However, Rijkswaterstaat reports in their latest monitor on interweaving that more research and testing is necessary for more successful implementation (Rijkswaterstaat, 2009). Interweaving and design team contract forms are both discussed in more detail in the literature study. It seems that even though there are several possible definitions for ECI, there is very little actual experience with the concept.

This thesis report continues with the research approach, providing the problem statement, goal of the research and the research questions that need answering to achieve this goal. Chapter 3 discusses the methodology used for the research and goes into detail on the Delphi method and why this methodology is chosen. The next chapter (4) is the literature study, going in depth on previous research. Chapter 5 provides the initial statements and definitions gathered from the Delphi scoping round and the literature study, which is used as input for the main part of the Delphi study. Chapter 6 shows the results of the Delphi study for each of the 3 topics; ECI definition, benefits and disadvantages and implementation. In chapter 7 the results are interpreted and concluding remarks are given regarding the study. Chapter 8 concludes the thesis report by discussing the results, the implications of ECI and suggestions for further research.

Definitions and explanations can be found in the main text or in the footnotes of the text. To prevent unnecessary searching, an overview of the definitions used in this thesis is provided in on page vii. The list of tables and figures can be found right after the table of contents on page xii and xiii.

2. Research Approach

The approach to the research on ECI is described below. It follows the guideline and requirements set for the CME 2000 graduation research of the master Construction Management & Engineering at the TU Delft (Schoenmaker & Verlaan, 2017). The first section starts with a problem statement, followed by the goal of the research. The chapter is concluded by the research question and supporting sub-questions. The research approach forms the "red thread" for the rest of the study.

This research is conducted as a collaboration between the TU Delft and Royal HaskoningDHV (RHDHV). The academic supervision of the research is done by the graduation committee members of the TU Delft. The practical part of the research is done by means of a graduate internship at Royal HaskoningDHV. This engineering firm provides the network and practical views required for this research. Because there will be several experts from RHDHV used in the Delphi panel, the short distance to these experts by working at the same company aims to reduce the attrition rate[1] in the Delphi study.

2.1 Problem Definition for ECI in the Netherlands

Following from the introduction above, current methods for public project delivery seem to have a lot of room for improvement. Cost overruns and delays seem to be more common than on-schedule- and within initial budget project delivery. ECI may help to improve project performance on several aspects. But it is unclear how ECI can help in the Netherlands. There is no clear definition set for ECI in the Netherlands yet, which makes it difficult to assess to which degree ECI is used already and what effect it had. Rijkswaterstaat and several sources in literature state that the direction of increased and improved forms of collaboration is positive, but that more research and development is necessary (Leendertse et al., 2012; Lenferink et al., 2012; Rijkswaterstaat, 2009; The Dutch Construction Sector, 2016; van Valkenburg et al., 2008).

ECI is implemented in other countries already. But as they may differ in culture, regulation and legislation from the Netherlands, their methods may not be effective or legal here. This requires research on the way ECI can be implemented in the Netherlands. There seems to be a basis for ECI already in construction projects in the private sector. Together with the examples from other countries, a way to implement ECI for public projects may be found as well. The reason why construction projects in the private sector can use ECI more easily than projects in the public sector lies in the procurement law. Applying ECI for public projects in the Netherlands requires adherence to EU directives and resulting national legislation.

The knowledge gap identified in **theory** is an unambiguous definition what ECI really is, what it should be and what the benefits for ECI then are. The identified knowledge gap in **practice** is the way the in-theory-defined ECI principle can be implemented in public construction projects.

2.2 Research Goal

The goal of this research is threefold; (1) to provide a definition for ECI to start discussion on ECI and help further define ECI for further research on ECI in the Netherlands. A clear definition may help to select existing cases in the benefits of certain aspects of ECI and, reduce the confusion and fill the knowledge gap in literature. Along with this definition, (2) ECI is said to have many benefits. But as ECI seems to come in many different shapes and forms, it is hard to pin down what aspects of ECI provide the benefits. And (3), this study aims to identify ways to implement ECI in public construction projects

[1] The attrition rate is the rate at which respondents stop responding to consecutive rounds of interviews. This is an inherent problem to Delphi studies.

in the Netherlands. To do so effectively, the research focusses on the perspectives of the client, the designer and the contractor[2]. Effectivity is defined by the recognition of the benefits and way of using ECI for all three perspectives. As the EU directives concerning public projects are required to be followed, the resulting advice on ECI should fit within the legal boundaries for these projects. The resulting ECI concept should either be ready for use in Dutch public construction projects or have the conflicts to prevent this implementation identified.

2.3 Research Questions

Based on the introduction and the sections above, the research question is:

"What is the potential of ECI in the Dutch public construction industry?"

In the research questions, the construction projects in the public sector consist of all projects set up and procured by a public entity, for more than 50% (Pianoo, 2018). This varies from for example infrastructure, schools, prisons, hospitals and others. Adding value refers to any gain in quality, cost, time or other specific positive effect on the construction project outcome. Effectivity here implies that the use of ECI in public construction projects is possible and that there are benefits recognized by the involved parties in these projects. The relation to Dutch procurement of infrastructure projects implies that the EU directives on the procurement of infrastructure projects are considered. Public construction projects for this thesis are all construction projects publicly procured.

Answering the research question requires the answer to the following sub-questions:

1. What is Early Contractor Involvement (ECI)?
2. What is the effect of ECI on construction projects?
3. What are the requirements for the implementation of ECI?
4. What are the implications of the use of ECI for the Dutch construction industry?

The research consists of a literature study and a practical, qualitative study to answer the questions above. The answer to the first, second and third question is sought in both literature and practice. To answer the fourth question, the results of the Delphi study are used as input.

The literature study aims at providing the initial information to answer the sub-questions and is used to start the practical research, so that the Delphi study can be executed efficiently. The answer to the fourth question should follow from the results of the Delphi study. The methodology of the research is described in the next chapter.

[2] These perspectives followed from the literature exploration on the involved parties in construction projects. The "designer" perspective includes what others may call the "engineer" or "consultant" (Chao-Duivis et al., 2013)

3. Research Methodology

This chapter describes the methodologies that are used in this thesis research. The methodologies used in this research are the following:

1. *Systems Thinking* (or the Systems Approach)
2. *The Delphi method*, and
3. Basic statistical analysis on the results of the Delphi study

These methods are discussed individually in their corresponding subparagraphs. The chapter is concluded by linking the results of these methods to their contribution to this research on ECI.

3.1 Systems Thinking

Defining ECI for construction projects in the Netherlands seems hard; in literature it has not been done unambiguously yet. To make everything as clear as possible, systems thinking is used. Systems thinking is a certain way of looking at a problem, by identifying and focusing on the critical elements. In essence, looking thoroughly at the nature and typology of the problem (Chen, 1975). More clearly, a system approach stems from *systems thinking*. Thinking in systems provides a way to communicate complex, interdependent knowledge, expertise and experiences (Richmond, 1994). A system, broadly defined, is "something that is more than the sum of its parts" (Meadows, 2009). So, following this reasoning, systems thinking is a systematic way to think about systems (Arnold & Wade, 2015). Systems thinking consists of elements (or characteristics), interconnections (or relations) and a function (or purpose) (Arnold & Wade, 2015). By combining system elements and different perspectives, construction projects can be fit with systems thinking. Arnold and Wade (2015) use the systems test to see if a system approach was appropriate. The visualization of this test is given in figure 2, below.

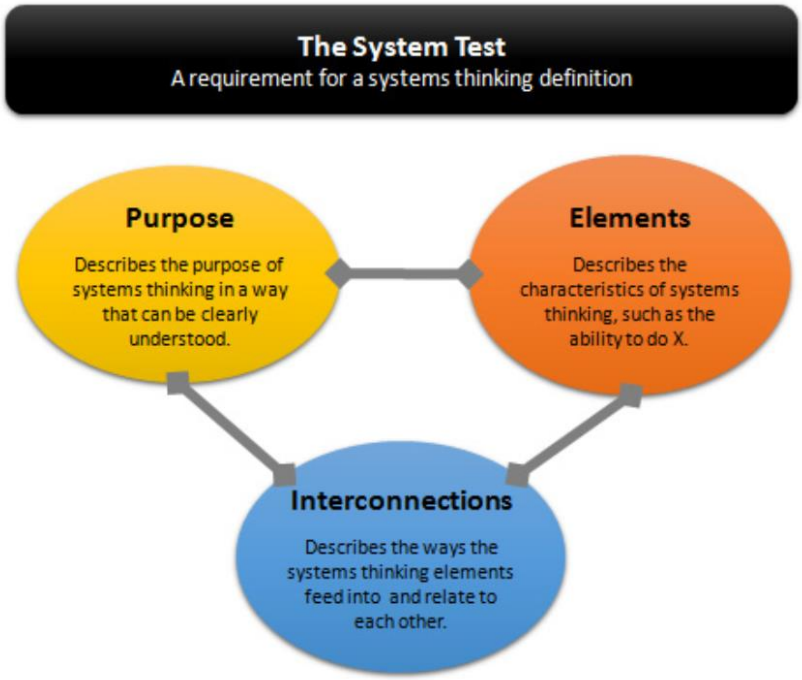


Figure 2: The Systems Test (Arnold & Wade, 2015)

- **Purpose (or function, goal)**: Should describe the purpose of the application of systems thinking in a clear and comprehensive way (Arnold & Wade, 2015). For this thesis, the purpose of

systems thinking is to clearly define a construction project in such a way that ECI can be discussed in relation to construction projects in a clear and unambiguous way. With systems thinking, it includes a visual representation of a construction project, which helps to quickly understand the implications of ECI.

- **Elements:** The elements are the building blocks manifested by systems thinking. When considering ECI, the building blocks are construction project elements. This is explained later, in chapter 5, *Scoping Round*.
- **Interconnections:** These connections explain the internal relations between the elements.

Systems thinking is visualized by Arnold and Wade (2015) to structure the approach in a systematic way. This 'systems thinking system' is presented in figure 3. The focus for this study lies primarily with part 3 (understanding system structure) and 7 (reducing system complexity by modeling systems conceptually). The application of the system in figure 3 is done in Appendix A. This appendix shows the different system levels and the aggregation to a simplified system, usable for most construction projects. The results of the systems thinking are shown and discussed in chapter 5, *Scoping Round.*

The system provides a theoretical framework that helps with the discussion and interpretation of the results during the study. By having this system available and discussed with all experts, they should possibly be able to formulate their response with the system in mind. The methodology as represented in figure 3 is used in the *Scoping Round* chapter. The input for the system is gathered from the literature study and expert's opinions in the scoping round interviews. The scoping round and expert panel are explained in the next section; *Delphi Methodology*.

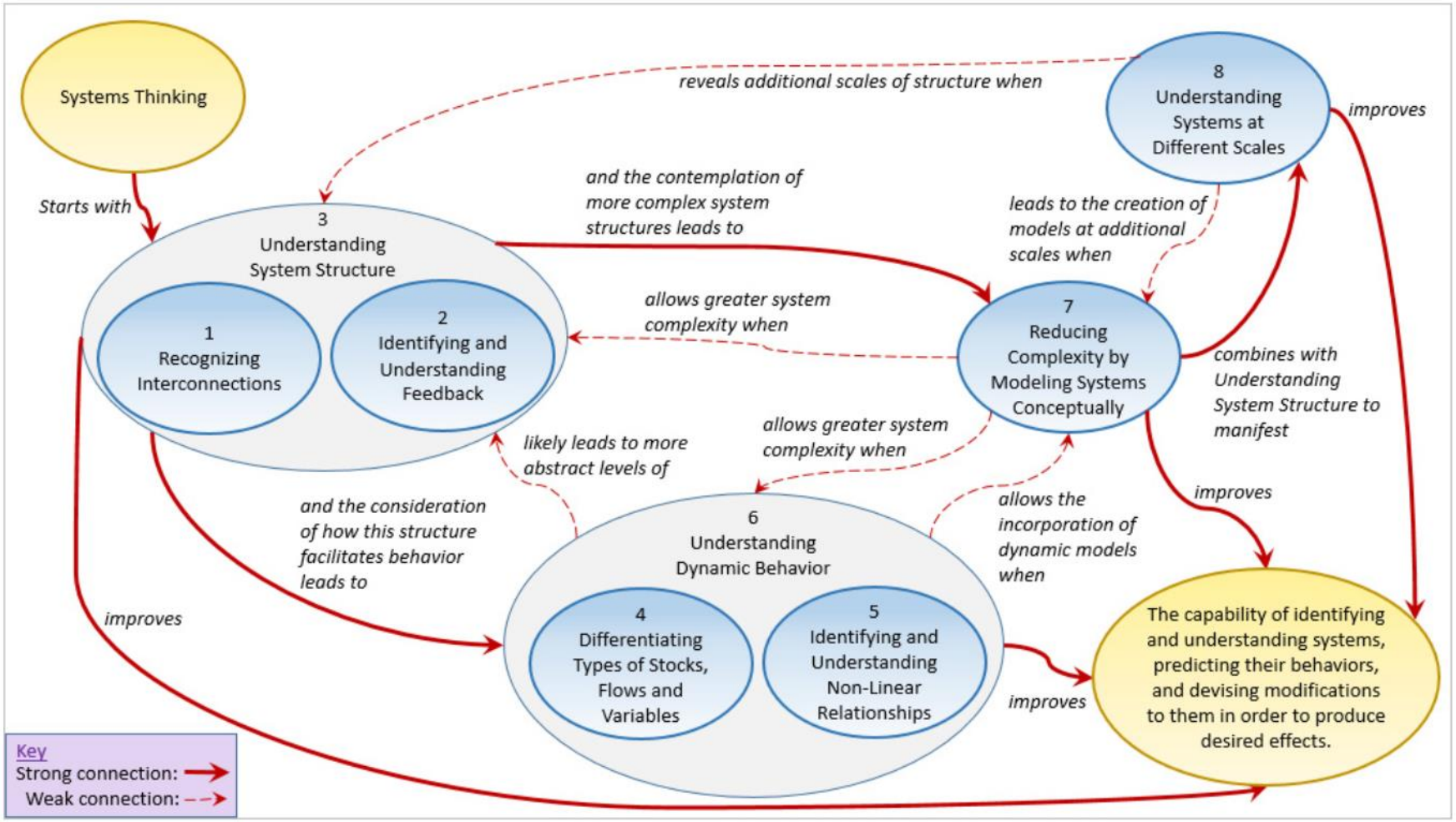


Figure 3: System resembling System Thinking (Arnold & Wade, 2015)

3.2 Delphi Methodology

The Delphi method refers to ancient Greece, where the oracle of Delphi would answer any question you had (Dalkey & Helmer, 1963; Thangaratinam & Redman, 2005). This principle was translated to an academic research method. In the 1950s, the RAND corporation developed a research method to assess the average number of atomic bombs that would be necessary to sufficiently destroy an enemy industry (Dalkey & Helmer, 1963; Linstone, 1985). The method focusses on reaching consensus between experts in the field of research, using an expert panel as the Delphi oracle of ancient Greece (Dalkey & Helmer, 1963). This consensus should follow from multiple rounds of interviews of experts. The iterations continue until either a predefined percentage of consensus is achieved or when results no longer improve (Donohoe & Needham, 2009; Pawlowski & Okoli, 2004). An example of what the basis of the Delphi methodology looks like is displayed in figure 4, below.

Figure 4: Basic Delphi Methodology

The strength of the Delphi method lies in the ability to address complexity in an area where definitions are imperfect and hard facts are lacking (Donohoe & Needham, 2009; Pawlowski & Okoli, 2004). When this is the case, results achieved from experts' intuition and opinion may be considered the second best to hard data (Dalkey & Helmer, 1963; Thangaratinam & Redman, 2005).

Another advantage of the Delphi method is the individual consultation of the experts. Because the experts are interviewed one by one, they can remain anonymous during the study and are therefore less influenced by stronger personalities or different expertise (Powell, 2003; Thangaratinam & Redman, 2005). Exclusion of these negative effects of group dynamics gives the Delphi method an advantage over group discussions. The setup of the Delphi method consists of individual interviews or questionnaires (Dalkey & Helmer, 1963). After each round the answers are given back for feedback, allowing the respondent to change their answer. The answers and feedback are then analyzed by the researcher. In the next round, definitions and questions are improved by the researcher and are again put in a questionnaire. This questionnaire is given to the individual respondents again, aimed at improving the degree of consensus in the expert panel (Pawlowski & Okoli, 2004). As there are several slightly different methodologies for conducting Delphi research available, the chosen Delphi method is discussed in more detail in the *Application of the Delphi Method* section.

The Delphi method has been under scrutiny from the academic society for questionable reliability, reproducibility and accuracy (Sackman, 1975; Schmidt, 1997). To address these valid points of critique, there are important disadvantages to mitigate whilst using the Delphi method to prevent scrutiny on the Delphi study results. The points of scrutiny are summarized as 5 disadvantages by Donohoe and Needham (2009), which are:

1. Results are highly sensitive to design characteristics of the methodology.
2. The assumption that experts will revise their judgement by the opinions of others may not be so.
3. High attrition rates may decrease the reliability of the results.

4. Consensus may shift towards the median of results due to lack of engagement or level of expertise.
5. Difficulty in deciding level of consensus or other criteria to stop the research.

From other literature, the reliability of the results is identified to rely on several essential factors in this type of study; expert selection, a predefined definition of consensus, and; proper description and execution of the iterative interviews (Pawlowski & Okoli, 2004; Sackman, 1975). Powell (2003) states that the inclusion of an overview of made decisions improves validity and reliability. Under the pressure from the academic society on the Delphi method, several changes to the Delphi methodology are proposed, like expert ranking and non-parametric statistics (Pawlowski & Okoli, 2004; Schmidt, 1997). The aforementioned sources from literature seem to agree that the expert selection is most important to proper Delphi research. Therefore, extra focus is given to the selection of the experts. The expert selection for this thesis research on ECI is discussed in the paragraph *Expert Selection* below.

The choice for the Delphi methodology for this research is made because there seems to be no clear definition in literature for ECI in the Netherlands. Due to the lack of unambiguous definition of ECI, it is difficult to discuss the principles and select case studies. A proper definition is therefore required. A preliminary definition of ECI can be obtained through exploratory individual expert consultations prior to the actual interviews and validated by the expert panel in the first round of the Delphi interviews. This follows the methodology proposed by several authors, which is visually represented in figure 5 (Donohoe & Needham, 2009; Powell, 2003).

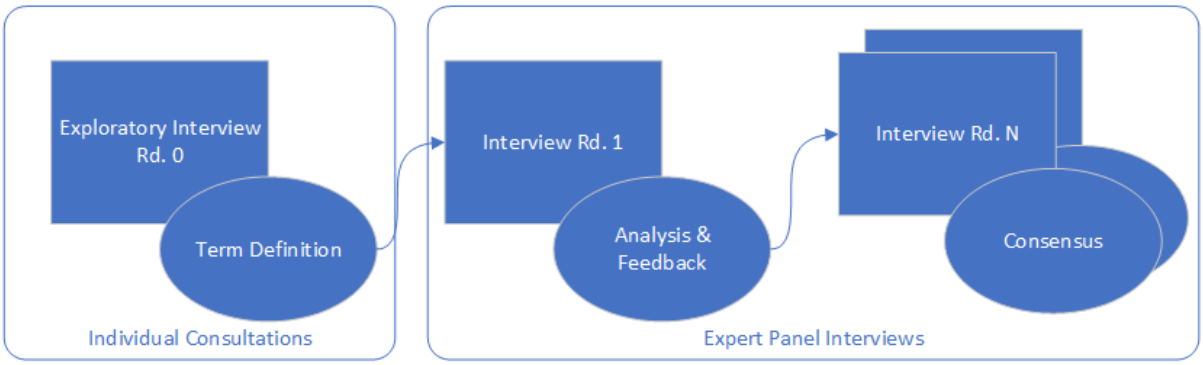


Figure 5: Delphi methodology with Scoping Round

3.2.1 Attrition

Something potentially problematic to Delphi studies is attrition. The attrition rate is the rate at which respondents stop responding per round of interviews or questionnaires (Donohoe & Needham, 2009; Powell, 2003; Thangaratinam & Redman, 2005). Several sources confirm that attrition is an inherent problem to Delphi studies (Donohoe & Needham, 2009; Pawlowski & Okoli, 2004; Thangaratinam & Redman, 2005). Mentioned attrition rates in literature vary for each study. As high attrition greatly diminishes the reliability of the results, it is important to try to keep attrition rates as low as possible by implementing mitigation measures. These measures are discussed later, in the *Application of the Delphi Method* section and Table 3. It is however expected that mitigation does not drop attrition rates to zero. The way to deal with the leftover attrition is to have some redundancy in the expertise of the panel and to take the remaining expertise when consensus is reached in account when analyzing the results of the study.

3.3 Application of the Delphi Method

The Delphi method can be tailor-made for exploratory research. But as discussed above, the methodology must be properly described and executed to provide reliable results. As there are several slightly different methodologies available, the best fit was sought for this thesis research. Donohoe and Needham (2009) have described the best practices and common pitfalls of Delphi studies in their 2009 paper. Considering the level of rigor, detail and the applicable type of research, the methodology as described by Donohoe and Needham (2009) was chosen for this research. This method focusses on the description and underpinning of what Donohoe and Needham (2009) call Critical Design Decisions (CDDs) for the methodology. According to them, making and describing these CDDs properly gives reliable and reproducible results.

The methodology as proposed by Donohoe and Needham (2009) and its implementation are explained in several parts. First, the general steps of the research are discussed. This is followed by an identification of the CDDs that must be made and the decisions that are made on those. Lastly, the common disadvantages of the Delphi method are listed and paired with their corresponding mitigation measures.

3.3.1 Methodological Application step by step

The Delphi procedure needs to be carefully planned and executed (Donohoe & Needham, 2009; Powell, 2003). A visualization of the procedure for this study is shown in figure 6. The preparation phase of the study requires the researcher to take five steps:

1. Define a problem statement and initial position of the research
2. Create the Delphi research design. In this design several Critical Design Decisions (CDDs) must be made. These are discussed in the section *Critical Design Decisions,* below.
3. Conduct a literature study on the subject. The literature study for this research can be found in chapter 4, *Literature Study*.
4. Conduct a scoping round, by means of interview or discussion with experts in the field. The consulted experts in the scoping round may help to identify experts for the expert panel.
5. Develop the criteria for expert selection for the expert panel.

The scoping round helps to set definitions and to test validity of the research early on (Donohoe & Needham, 2009; Powell, 2003). These first 2 steps provide the researcher with a sufficient base of knowledge for the Delphi research on the subject. It may also provide a start for the selection of other eligible experts for the Delphi panel, which is a part of step 3.

The selection of the experts lays the basis for the interpretation of the results of the research (Donohoe & Needham, 2009). The selection of the expert panel is therefore most important for the research design. The criteria for expert selection are distilled from the goals of the research; setting a clear definition for ECI, identify ways to achieve the benefits of ECI in public construction projects in the Netherlands and find ways to implement these. Achieving this requires experts from the perspective of client, designer and contractor. It also requires an academic basis to help define ECI in a way fit for both practical and academic use. This means experts in the field of public construction projects who can think on a conceptual level need to be part of the expert panel as well. Reproducibility of the expert panel requires a common denominator in the criteria. Embedded expertise may come at the price of reduced innovation. Therefore, the combined expertise in the panel benefits from using young professionals as well as seniors. The combination of these aspects gives the following criteria; eligible experts are people whom…

- Are available to participate in the expert panel
- Are willing to participate in the Delphi panel (1-hour personal interview, 2 30 minute (max) digital follow-ups)
- Can think on a conceptual level
- Fit in one of the expert groups (Client, Contractor or Designer)

The next phase in the study is called 'convergence' by Donohoe and Needham (2009), which can be seen in figure 6. This is the main body of the Delphi study, consisting of conducting iterative interviews with the experts selected in the panel (Donohoe & Needham, 2009). During the rounds of interviews, the researcher should monitor the attrition rate. Mitigation against attrition is discussed in the *Disadvantages to Delphi and their Mitigation* section below. The researcher analyses the responses and checks if consensus is reached (definition of consensus is a CDD). If consensus is reached, the Delphi study is terminated, and the final analysis of the results commences. If consensus is not reached, the next questionnaire is prepared with updated statements and distributed with a summary of the results of the previous round (Donohoe & Needham, 2009). These rounds continue until consensus is reached, a predefined number of rounds are conducted (which is a CDD), or when analysis shows that no improvement on consensus is achieved between rounds.

The final phase consists of the analysis and interpretation of the questionnaire results and the reached degree of consensus (Donohoe & Needham, 2009). This involves statistical analysis (where possible) and interpretation of the results of the convergence phase. The results are then reflected against the initial problem statement and research question. The study is concluded with a final consensus statement to the panel and presentation of the results (Donohoe & Needham, 2009).

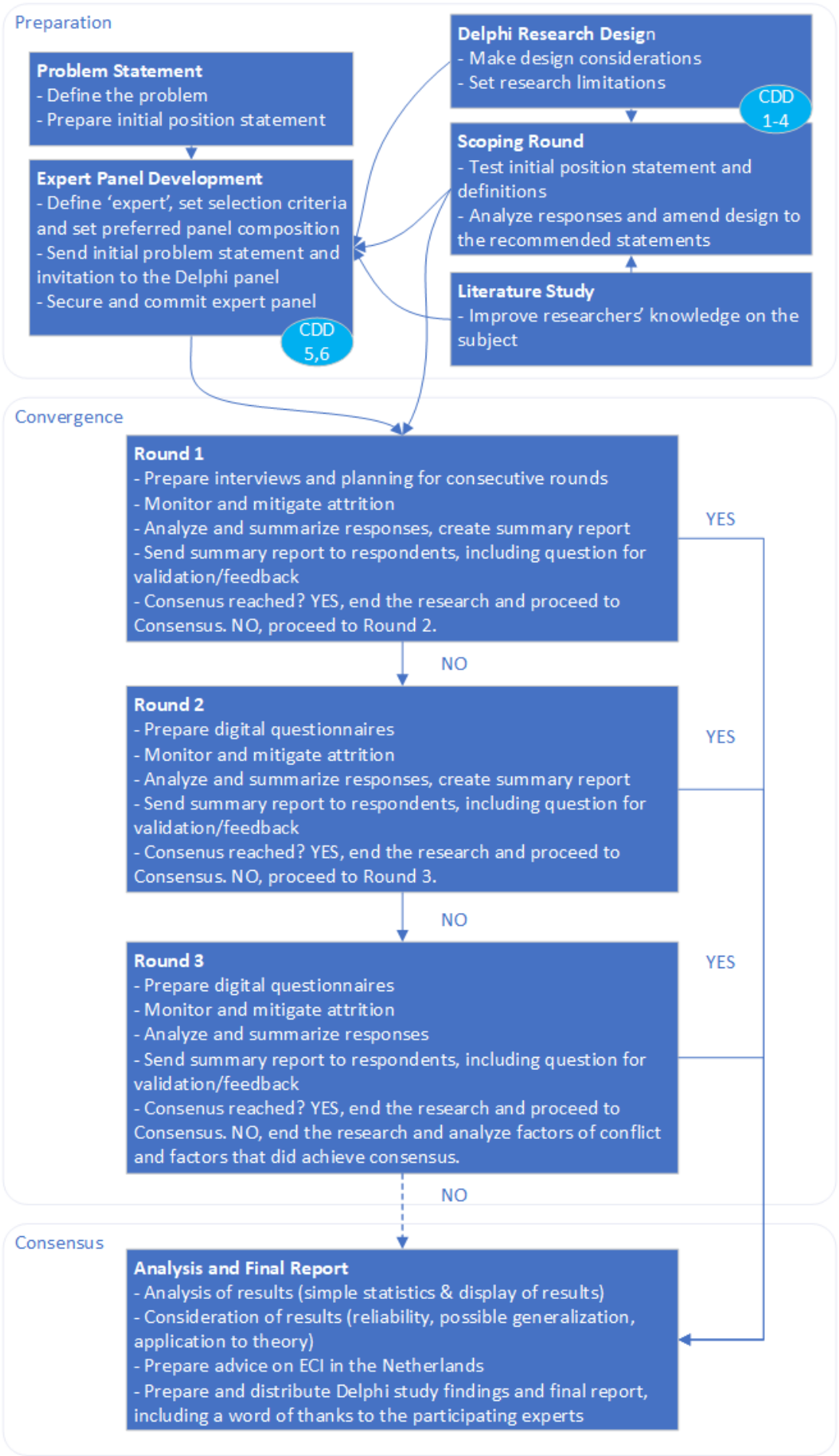


Figure 6: Delphi methodology for this research

The creation of the interview questions in the early rounds (scoping and first round) is aimed at gathering information and defining what ECI is or should be in the Netherlands. Most questions in these rounds will be open and allow discussion. Analysis of the results of these interviews yields definitions for ECI, characteristics of ECI and possible ways of implementation for ECI. These findings are summarized and sent as feedback to the respondents for review. This immediately either validates the results or suggests improvements. The later rounds test the analysis done by the researchers. This is done with the use of closed questions and Likert scales. The analysis of these results is done statistically where possible. Summaries are sent with the next interview. The primary interviews are done in person, whilst the secondary rounds are done digitally. The design of the interviews can be found in the appendices (Appendices B, C, D).

The presentation of the results between rounds is done by summarizing and analyzing the responses. These summaries are presented in the *Results* chapter. These results form the basis from which the conclusions of the research are drawn, in the form of answers to the research questions.

Validation of the results in a Delphi study is difficult, as the method is applied to areas where hard facts are lacking (Fink, Kosecoff, Chassin, & Brook, 1991; Powell, 2003). According to Fink et al. (1991) and Powell (2003), Delphi methodology should therefore be validated differently than 'hard science'. It is important to realize the results of a Delphi study represent expert opinion rather than fact, which in this study is the best available option (Powell, 2003). Donohoe and Needham (2009) acknowledge this and state that the expertise of the expert panel should be considered in the validation of the results as well. Therefore, careful selection of the experts and description of the combined expertise is required for validation. The experts validate the results by giving feedback on the researchers' analysis of their responses. As mentioned above, a summary of the results is sent to the respondents at the end of every round. Feedback on this summary is considered and applied to the results of the study of that round. The form for the internal validation as described above is done implicitly in the questionnaires, to reduce the required time for the experts to participate in the research.

As the Delphi method is not often used in thesis research, the results of the research are tested externally in a confirmation session. This confirmation of the results is done by Prof. dr. ir. M.J.C.M. Hertogh. This academic professor on integrated project management at the faculty of Civil Engineering and Geosciences has practical experience in the field of infrastructure projects, experience as researcher on large infrastructure projects and has an advisory role for Rijkswaterstaat. This multitude of roles make mr. Hertogh a fitting candidate for a confirmation session of the results.

3.3.2 Critical Delphi Design Decisions

The CDDs lay the basis for the way the Delphi study is conducted. There are several decisions that have to be made, of which some are set arbitrarily and other logically. Table 1 shows an overview of the CDDs for this Delphi study and their implications. The considerations and assumptions for the choices made on the CDDs are given following the numbering in Table 1.

Table 1: Critical Design Decisions (CDDs)

Critical Design Decisions			
#	**Subject**	**Implications**	**Choice**
1	Use of a scoping round	A scoping round is suggested to set definitions. This scoping round is not taken into account for the convergence phase and does therefore not require specific methodology. The scoping round can be filled with interviews and discussions with available experts, who are not necessarily part of the expert panel. The aimed results are clear definitions and understanding of the topic.	**A scoping round will be used**
2	Maximum number of rounds	Setting a maximum number of iterations restricts the duration of the research and possibly the degree of consensus reached. The maximum may help to prevent the Delphi study to go on longer than is effective and therefore becoming a waste of time.	**Scoping round + max 3 rounds**
3	Degree of consensus	Predefining a degree of consensus for generalization of the results improves the reliability of the Delphi study. The level of consensus can be set arbitrarily, if it is explained why.	**75% or more of the experts must agree for consensus; 50% or more for a degree of consensus; less is considered as no consensus**
4	Used scale in the interview and questionnaires	The chosen scale determines the type of statistical analysis of the results, both during the convergence and consensus phase. The choice is between dichotomous scale (yes/no) and a Likert scale (agree on a scale of 1-5)	**Dichotomous scale, as a small panel size gives no solid ground for advanced statistics.**
5	Size of the expert panel	The size of the expert panel determines the reliability of the research, together with the expert selection criteria. The panel size also sets the duration of the first round of interviews. The expected attrition rate is important to be taken into account to end the study with a sufficient number of respondents. Redundancy helps to diminish the impact of attrition. Sufficiency is deemed subjective in literature and is left for interpretation of the researcher.	**The aim is 12 experts. This number may change due to practical reasons.**
6	Expert selection criteria	The selection criteria of the expert panel determine the value, reliability and applicability of the results. The choice, underpinning and description of these criteria lay the basis for the reproducibility of the research.	**Availability, willingness, ability to think on conceptual level and fits in the perspective of client, contractor or designer. See section 3.3.1.**

1. The choice for a scoping round implies that before the actual interviews take place, interviews take place with appropriate experts in the field of research. As they are not part of the results, the methodology of this scoping round is loosely defined. The main goal following the reasoning of Donohoe and Needham (2009) is to set the definitions used in the Delphi study, so that interpretation for the respondents is clear. In addition, this round is used to gain practical insight in the subject which cannot be gained from literature. The experts selected for the scoping round are not necessarily selected with the same rigor as for the expert panel.

If experts consulted in the scoping round fit the selection criteria however, they may be invited to the expert panel as well. The three experts consulted in the scoping round are:

I. Prof. mr. dr. Monika Chao-Duivis – Professor construction law at the section Management in the Built Environment of the TU Delft, and director of the Institute of Building Law (IBR).
II. Prof. Anna Kadefors – Professor Real Estate Management at the department of Real Estate and Construction Management at the KTH Stockholm and guest professor at Chalmers University. Anna Kadefors contributes to Swedish research on ECI.
III. Ing. Sander Jacobs – Contract- and Project Manager at Royal HaskoningDHV, working on a new contract type for public projects.

2. Due to the time set for thesis research (6 months in total), the maximum number of rounds for the research has to be predefined. This avoids the research to drag on too long, but also may prevent reaching consensus. If consensus is not reached, this research aims at identifying the factors preventing consensus and suggest specific further research.
3. The degree of consensus is set according to the expert panel size and the available time to reach consensus. By using a scale for the degree of consensus, the research aims to separate relative certainties from possibilities.
4. The size of the expert panel is discussed thoroughly above, in the *Methodological Application* section. The assumed attrition rate for this study is 15% per round. The implication of this rate and of slightly higher and lower rates can be found in Table 2. As discussed earlier, the value of the results decreases as the expert panel shrinks, so attrition needs to be kept low.

Table 2: Example attrition rates and their effect

Respondents at start	12	12	12
Rounds	3	3	3
Attrition Rate per round	20%	15%	10%
Respondents at end	6	7	9

5. The expert selection criteria come from the availability of experts, aspects of construction that are affected by ECI and the people who work on public construction projects (project managers, contract managers, engineers, consultants and clients concerned with public projects).

Table 3: Pitfalls and Disadvantages of a Delphi Study

Pitfalls and Disadvantages of a Delphi study		
Pitfalls and Disadvantages	**Probability & Impact**	**Mitigation Measures**
1. High sensitivity of design characteristics (panel composition & expertise, question clarity, outlier management and	Very high: The CDDs lay the basis for form of the research, the interpretation of the results and the reproducibility of the research.	A. Meticulous assessment of the CDDs
		B. Balance is considered in the expert panel selection
		C. Scoping round to set definitions and test questions
2. Assumption that experts will revise their judgement by the opinions of others does not hold	Medium: The chance is low but the impact would make achieving consensus impossible	D. Explain the methodology and goal of the research in the first round of interviews and ask for coöperation in this
3. High attrition rates	High: Attrition seems unavoidable; the degree of attrition will affect the reliability and interpretation of the results	E. First round of the interviews is done personally, further rounds digitally
		F. Deadlines will be set, made part of the planning, and communicated during the first round of interviews
		G. Downtime will be kept short between rounds (aim at 2-3 weeks between rounds)
		H. Reminders will be sent when necessary, as well as contact by phone when deadlines are missed
		I. Questionnaires are kept short (aim at 15 minutes at most)
		J. Redundancy in panel size
4. Consensus shifts towards median of results due to lack of engagement or considered expertise	Medium: This may happen and is hard to measure if it does. It will decrease the accuracy of the results, but it is unlikely to invalidate the results.	See C & D.
5. Deciding on level of consensus or stopping criteria proves difficult	Low: Level of consensus is defined beforehand in the CDDs and the stopping criteria are defined according to the available time for research. This implies that research may be terminated before consensus is reached.	K. Agreement for consensus and maximum number of iterations are set in the CDDs
		L. Identification of conflicts preventing consensus helps further research on the subject

3.3.3 Disadvantages to Delphi and their Mitigation

Donohoe and Needham (2009) defined several disadvantages or pitfalls for Delphi studies. These are the same disadvantages as presented earlier in this chapter. To increase the chance of conducting the Delphi study successful, these disadvantages and pitfalls are considered in terms of risk and mitigation measures. This is shown in Table 3.

3.4 Selection of the Expert Panel

The selection of the experts for the panel followed the criteria set in the *Methodology* chapter. The selected experts…

- Were available to participate in the expert panel
- Were willing to participate in the Delphi panel
- Can think on a conceptual level
- Fit in one of the expert groups (Client, Contractor or Designer)

The search for the experts was done using the company network of RHDHV and the network of 2nd supervisor ir. L.P.I.M. Hombergen. The initial expert panel consisted of 12 experts from different organizations like Rijkswaterstaat, Royal HaskoningDHV, Bam Infraconsult and Dura Vermeer, shown as perspectives in figure 7. The characteristics of the expert panel are summarized in table 6. The different roles represented in the expert panel[3] gave a decent distribution of perspectives to approach ECI.

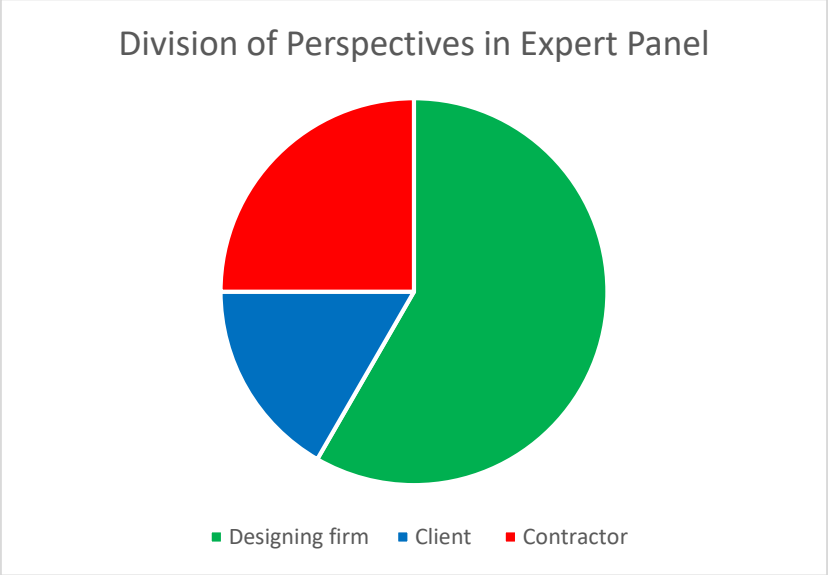


Figure 7: Division of the perspectives in the expert panel

Table 4: Expert panel characteristics

	Designing firm[4]	**Client**	**Contractor**
Experts	7	2	3
Experience in roles	Project manager, process manager, contract manager, purchasing manager, project director, purchase director	Purchase strategy advisor, contract advisor, project manager	Project director, procurement manager, project manager, purchase manager
Experience domain	Public & private	Public	Public & private

[3] Some of the experts had experience in multiple roles
[4] The term designing firm does include engineering bureaus, as is stated in page 5.

There are several reasons for the large share of experts from the designer perspective:

- The company at which the thesis study was conducted had a large internal network with many people fitting the criteria. Especially the willingness of most to participate in the research contributed to the high number of experts from this group. It must be noted that although most experts in this group come from Royal HaskoningDHV, one of the experts came from another design/engineering firm.
- Approached experts for the other perspectives from different companies or municipalities did not respond or decline the invitation to the panel. As time was a constraining factor, the willingness to participate from experts from the designer perspective increased their share greatly.
- Especially the required conceptual level of thinking equired for this research was present in this group of experts. As several of the experts had experience in both the public and private sector; and both at the contractor and the client, they were able to reason along the lines of the other perspectives as well. However, there still is a difference in reasoning between the perspectives, which is taken into account in the *Discussion* chapter.

3.5 Connecting the used Methodologies to the Research

The methodologies discussed above create the foundation for this research in different ways. Systems thinking helps to specify ECI in relation to construction projects in the Netherlands. With system elements, relations and purpose unambiguously defined, and the visualization of a construction project as a system, the Delphi study can start using the specified system as a basis to apply the results of the study. The Delphi study uses experts' opinions on ECI to assess its effectivity in construction projects and to give advice on how ECI can be implemented for public construction projects. The results from the studies are reflected on the system for construction projects, reflecting practice on theory.

4. Literature Study

The literature study on ECI in this chapter starts by identifying the trend in construction projects leading to ECI. This trend is then connected to ECI practices globally, including an early definition of ECI. Then, the different views on what ECI is in the Netherlands are discussed. Next, the advantages and disadvantages of ECI are identified and linked to ECI. This includes identification of possible barriers for implementation of ECI in the Netherlands. Concluding this chapter is a short discussion on (public) project characteristics.

4.1 The Trend of Public Construction Projects

Famous research on public infrastructure projects showed that these projects experience delays and cost overruns excessively often (Flyvbjerg et al., 2002). Flyvbjerg et al (2002) state that this comes from optimism bias and strategic misinterpretation in the public works. Other research acknowledges the problems in public works, but state that it comes from design errors and the culture in the construction industry (Love et al., 2012). Love et al. (2012) state that the initial design of the works is correct, but the errors come as the design is changed again and again. Many are affected by the poor performance of public construction projects and call for change.

A trend identified which is aimed to improve the performance of construction projects is collaboration (Boes & Dorée, 2013; Eriksson & Westerberg, 2011; Love, Davis, Edwards, & Baccarini, 2008). The trend of collaboration to improve construction projects has a wide base of views for the 'how' to do so. Partnering, Public-Private-Partnerships, Design Teams, Interweaving and ECI are all methods named as possible ways to improve construction projects through collaboration (Klijn, 2009; Lahdenperä, 2012; Schoenmaker, Verlaan, & van den Boomen, 2017). All stem from the same principle; teamwork improves the project. Breaking down why collaboration can improve construction projects shows plenty benefits. Some examples are:

- Collaboration improves teamwork and therefore project performance (Eriksson & Westerberg, 2011; Suprapto, 2016)
- Improved collaboration early in the process helps to divide risks better (de Ridder, 2009; Love et al., 2008)
- Collaboration and teamwork reduce contractual conflicts (Kamminga, 2012)
- Collaborative project execution helps to innovate in construction projects (Knutsson & Thomasson, 2014)
- And there are more.

As research and experience show that collaborative efforts pay off, more and more parts of construction projects change to a teamwork-oriented approach. Traditional contracts shift more to relational or Design-Build contracts (Scheepbouwer & Humphries, 2011). There are globally many efforts being made to achieve the collaborative benefits in projects. One of the methods to achieve higher value for money and improve project delivery times is ECI (Love et al., 2008).

4.2 Global use of ECI

According to literature, ECI was first implemented in the UK (Rahmani, Khalfan, & Maqsood, 2013). The UK Highway Agency implemented ECI in 2001 and ECI became a part of the NEC (NEC, 2016). Other countries that implement ECI according to literature are Australia, New Zealand, the Netherlands, Sweden, Norway and the US (Rahmani et al., 2013). As there is more literature available on ECI in the UK, Australia and New Zealand, the focus is on these countries. ECI in the Netherlands is discussed in the next subchapter.

UK: After bad experiences in the road and water sector of the UK, the Highway Agency decided to exploit best practices according to the NEC (NEC, 2016; Rahmani et al., 2013). This realized a shift from D&B and DBFMO delivery methods to ECI[5] (Rahmani et al., 2013). According to Rahmani et al. (2013), ECI is recommended for use to decrease project duration, promote innovation, value management and to minimize claims.

The UK uses a two-phase model[6], but differently from the Australian model which is discussed below (Mosey, 2009, 2014; Scheepbouwer & Humphries, 2011). The first phase consists of the design and planning of the works. The first stage is procured using a capability assessment toolkit evaluating past performance, using non-price criteria. The client and the contractor work on an open-book basis for the development of a target price. Scheepbouwer and Humphries (2011) explain that the incentive for the contractor is a pain-gain share formula to execute construction for the target price within this agreed upon target price budget in the first phase. Two key steps for the ECI basis in the UK are (Rahmani et al., 2013; Scheepbouwer & Humphries, 2011): (1) Qualifications based selection of design and construction parties after completion of feasibility plans, and (2) Development of an open-book target pricing system, forming the fixed price for the second phase, which are the physical works. The first phase is conditional, where continuation of the contract is based on reaching agreement on the target price developed in the first phase (Rahmani et al., 2013). The second phase is unconditional construction, either with the contractor present in the first phase if agreement on the price is reached or with a new contractor after a traditional tender (Rahmani et al., 2013).

Australia: ECI in Australia is different from any project delivery form used before in Australia (Love et al., 2008, 2014; Rahmani et al., 2013). Public bodies in Australia used almost exclusively traditional lump-sum contracts, as they viewed it as the only proven method to work for them (Love et al., 2008). Continuous pressure from their own construction industry and collaborative methods implemented elsewhere resulted in their own innovative approach to ECI (Davis, Love, & Baccarini, 2008; Rahmani et al., 2013). The innovation in the approach is a way for the public authorities (who were not ready to adopt a full collaborative approach) to demonstrate value for money and having a Target Outturn Price (TOC) (Rahmani et al., 2013). This TOC differs from the lump sum prices previously used providing more flexibility without losing face (Love et al., 2008). According to Rahmani et al. (2013), the Australian ECI model is a hybrid between the more traditional model and the UK model.

In Australia a successful methodology for ECI has been structured in such a way that there are two separate phases: (1) Design development, and (2), Design and Construction. In the first phase a contractor (or consortium of consultants and contractors) is selected on non-price criteria, but with a TOC set (Rahmani et al., 2013). Phase 1 starts similar to an alliance contract (Scheepbouwer & Humphries, 2011). When the design is finished for 70%, phase 1 ends. Then negotiations start for the price of construction, based on the TOC (Scheepbouwer & Humphries, 2011). If an agreement is reached, the contractor gets the contract for construction resembling a typical D&B contract. When no agreement is reached, the contract for construction goes to the market (Rahmani et al., 2013; Scheepbouwer & Humphries, 2011). The difference with the UK 2-phase model is the determination of the price (the TOC is not used in the UK) and the specified moment of a 70% completed design between the phases.

[5] The UK implemented ECI as a project delivery method. Literature also states it is a form of contract. For clarity, this thesis regards ECI still as a principle, not a contract type, form of procurement method or delivery method.

[6] Further reference to the two-phase model refers to the UK concept of ECI. Literature also refers to the 2-phase model as the 2-stage model or UK model.

New Zealand: The ECI methodology is still being tested and improved in New Zealand (Scheepbouwer & Humphries, 2011). The current ECI structure used by the New Zealand Transport Agency (NZTA) divides the work in three separate portions: (1) Investigation and Research, (2) Preparation of a detailed design, negotiation of commercial terms (including price) and contract duration, and (3) Completion of the detailed design and physical works (Rahmani et al., 2013; Scheepbouwer & Humphries, 2011). The first two phases are procured similarly to the Australian model, but as the traditional contracts between the two countries differ, the ECI methodologies differ in practice as well. For example; Alliance contracting is used very differently in New Zealand than in Australia (Scheepbouwer & Humphries, 2011). The third phase does again represent a typical D&B contract.

These three countries have developed distinct ECI procedures. Several other countries have implemented ECI procedures, very similar to the practices described above (Rahmani et al., 2013). However, ECI is only scarcely implemented in the EU. Implementation of ECI as described above under current EU directives seems difficult, as the Norwegians experience (Wondimu, Hosseini, et al., 2016). The Netherlands have several approaches to ECI in place, which are discussed in the next subchapter. It has to be said that the US regards the ECI practices in the EU as progressive (Cox et al., 2002). Cox et al. (2002) state that the US can learn from the collaborative approach to public contracts which is promoted in the EU on the highest levels.

Next to the ECI practices that are identified above, there are several other practices that are sometimes called ECI. These are briefly described as well, as they may be discussed by the Delphi expert panel later. Alliance contracts, partnering and integrated project delivery (IPD) also have early involvement of contractor and designer, to different degrees (Lahdenperä, 2012). Lahdenperä (2012) calls these approaches *relational contract forms*.

- **Partnering** is a governance approach between two or more parties to achieve a specific goal, based on mutual objectives, an agreed method of resolution and active search for continuous improvements (Eriksson, 2010; Lahdenperä, 2012).
- **Project Alliancing** (or **Alliance contracting**) is a method to deliver projects with a team in cooperation, with good integrity and faith, making best-for-project decisions and sharing the outcomes of the project (Lahdenperä, 2012).
- **Integrated Project Delivery** is a contractual delivery method between owner, designer and contractor where risk and benefits are shared. Integration of expertise, systems and business practice lay at the basis of this method (Lahdenperä, 2012).

The differences in a nutshell between the relational contract forms are given in relation to each other. Partnering focuses on cooperation between parties but is based on traditional frameworks, like D&B contracts (Lahdenperä, 2012). The partnering charter is the distinctive aspect from partnering to traditional methods. Compared to Alliances, the parties in a partnering contract are more independent. The profits for Alliances are shared and more dependent on project success than the partners in partnering are (Lahdenperä, 2012). Integrated project delivery seems to be very similar to alliancing, but this novel method takes things even further by integrating systems and practices more actively than alliancing or partnering (Lahdenperä, 2012).

4.3 Dutch versions of ECI

Several sources in literature state that a form of ECI has been implemented in the Netherlands, even before its actual use in the UK (Scheepbouwer & Humphries, 2011; Song et al., 2009). They seem to be unclear however on what ECI in the Netherlands looks like. According to Dutch sources, there are two main procedures which are called ECI; (1) Design team and (2) interweaving (Chao-Duivis et al., 2013; Leendertse et al., 2012; Lenferink et al., 2012; van Valkenburg et al., 2008). There are other practices

which are called ECI, like hiring a contractor as a consultant using a market consultation (Leendertse et al., 2012) or a certain setup in a design & build contract (van Huuksloot, 2014). As these are mentioned a lot less as "Dutch ECI", the focus is on the design team and interweaving procedure. There is a third alternative that qualifies for Dutch ECI, which is *Plan, Design & Construct* (PDC). PDC will also be discussed in this section.

4.3.1 Design Team

The definition of the Design Team is "a temporary partnership on an equal footing between representatives of the roles in the building process of initiation, design and execution, where the participants in a coordinated manner perform the tasks arising from their particular roles and on top of this, where possible, assist their fellow participants to perform their tasks by giving advice" (van den Berg, 2007). It is important to note here that the main characteristic of early collaboration lies in parallel with the core of ECI; the design is made with input from the contractor (Chao-Duivis et al., 2013). The design team consists of representatives of the three roles in construction projects, i.e. the client, the contractor and the designer. From earlier research became clear that the use of a Standard Contract (UAV) does not work with the assumed equality between the client, designer and contractor (Chao-Duivis, 2012). More specifically, the relations between the client and the others are not equal to the relations between the designers and contractors. The current design team procedure stems from 1992 and is laid down in the VGBouw (de Koning, 2018). It has to be noted here that this procedure is not up to date with the recent revisions of procurement law (Chao-Duivis et al., 2013).

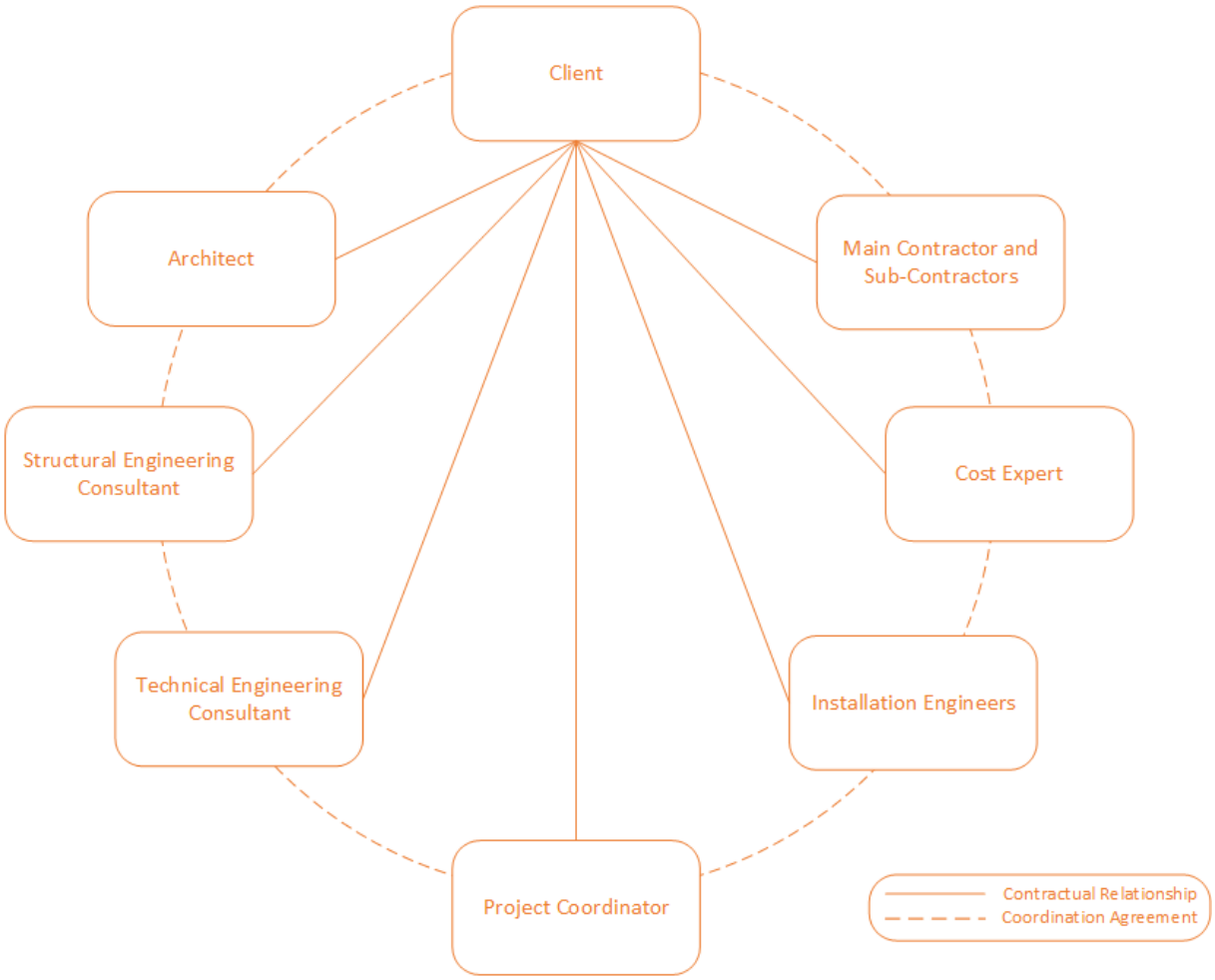


Figure 8: Visualization of the Design Team (figure based on Chao-Duivis et al., 2013)

A more detailed look at the design team shows that the client has a contractual agreement with all parties involved in the construction project, connected through a coordination agreement (Chao-Duivis et al., 2013). Figure 8 shows the hierarchical leadership position of the client from the contractual connections and a coordination agreement. An advantage of signing a coordination agreement is that an appointed entity responsible for the coordination has the tools to enforce the coordination agreement (Chao-Duivis et al., 2013). The design team has a multidisciplinary nature, bringing the expertise of the different parties together in consultancy roles (van den Berg, 2007). The added value here is that the client, contractor and designer come into contact very early in the project, where expertise and knowledge can already be shared. This enables more efficient execution of various tasks in the construction phase. The added value for the contractor is the additional work earlier in the project and increasing his chances in being awarded the construction contract (Chao-Duivis et al., 2013). The work is of a different kind than ordinary construction work, which may both be a learning experience for the contractor and a barrier to enter such an agreement as it is more like consultancy than construction. It is important to note here that during the scoping interview with Monika Chao-Duivis it became clear that there is no rule for reward of the contractor when the contract is not awarded. There is some compensation for the provided work, but this is mostly not in full.

The specific different roles in the Design team are the following:

- The role of the client is leading the design team. This can either be done by the client or a hired representative. The responsibilities of the client are aimed at leading the team and collaborating for a smooth construction process (Chao-Duivis et al., 2013).
- The role of the contractor in the early phases is to use his expertise for advice on the project in terms of costs, technical- and financial feasibility and design alternatives.(Chao-Duivis et al., 2013).

Another important part of the design team is the way the liabilities of members are organized. A participant of a design team is liable for error in his area of expertise and several other areas. Chao-Duivis (2013) states that the liability in teamwork settings can prove to be problematic. Stating which liability regulations are followed on entering the design team may help to mitigate possible conflicts (Chao-Duivis et al., 2013).

The design team was unpopular in the period after the construction fraud in the Netherlands (Boes & Dorée, 2013; Koenen, 2017). Lately it seems that the design team is making a comeback (de Koning, 2018). De Koning (2018) states that ambiguous definitions and combined use of design team procedures and integrated contracts prove problematic. An update of definitions and procedures is therefore deemed necessary.

4.3.2 Interweaving

A different interpretation of ECI in the Netherlands is interweaving (Leendertse et al., 2012; Lenferink et al., 2012; van Valkenburg et al., 2008). Traditionally the inclusion of the contractor in the project is done after the EIA procedure is finished and with that the detailed design and the final route decision are completed (van Valkenburg et al., 2008). The consequence of this approach is that contractors have no flexibility for input, and therefore innovation. Interweaving aims at involving the contractor before decisions are made permanent, which can be done in three ways (van Valkenburg et al., 2008). The first is called *parallelization*[7], where the procurement of the project starts parallel to the EIA procedure (van Valkenburg et al., 2008). No information is exchanged between the EIA procedure and

[7] This is a form of interweaving, not a different procedure.

the tender procedure. The second is called *interweaving*[8]. In this option the tender procedure and EIA procedure are 'interwoven', coordinating and exchanging information between the two (Lenferink et al., 2012; van Valkenburg et al., 2008). The third way refers to the UK's 2-stage model, where a contractor is selected before the design is made (Rahmani et al., 2013; Scheepbouwer & Humphries, 2011; van Valkenburg et al., 2008). The 2-stage model is explained in the subchapter *Global use of ECI* above.

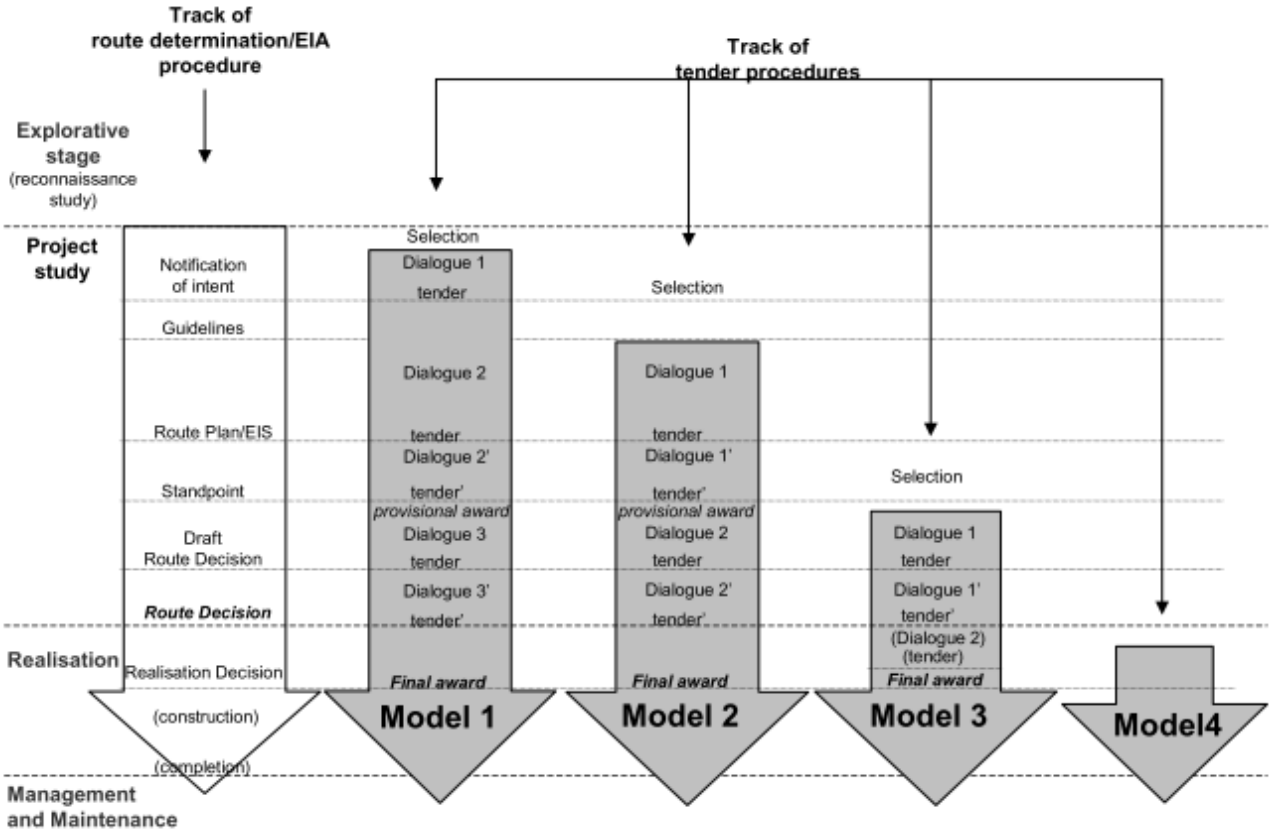


Figure 9: Visualization of possible interweaving options (Valkenburg et al., 2008)

According to Valkenburg et al (2008), the success of the first two forms of interweaving requires room for creativity, exchange of ideas, and synchronized procedures of EIA and tendering or design of the project. The difficulty here is to prevent both procedures from going off track, diverging to different designs or decisions. For parallelization this requires intensive management of both procedures separately, as there is no formal exchange of information (van Valkenburg et al., 2008). Figure 9 visualizes the different models for interweaving. However, the figure does not visualize the design process, but it can either be assumed to run in parallel to, or to be part of (*interweaved in*) the EIA procedure.

During the EIA procedure, there are three possible stages for interweaving or parallelization to start (van Valkenburg et al., 2008): The *Notification of Intent (definition phase)*, the *EIA study phase* or the *Draft Route Decision* (see the models 1-3 in figure 9). The trade-off in the type and timing of the interweaving procedure is essentially between creating and exploiting the opportunities of innovation, and the reduction of (political) risk in the project (van Valkenburg et al., 2008). Valkenburg et al. (2008)

[8] This is also a form of the catch-all term 'interweaving', which both are framed under ECI according to (Leendertse et al., 2012; Lenferink et al., 2012; van Valkenburg et al., 2008).

state that the most important pre-condition for the use of interweaving is for the client to know what they want before the tender procedure starts.

Interweaving is being used in the Netherlands by Rijkswaterstaat (Rijkswaterstaat, 2009). As this progressive method is still quite new in the Netherlands, its being monitored and improved as projects use this method (Rijkswaterstaat, 2009; Samenwerkingsverband opdrachtgeversforum in de bouw en Bouwend Nederland, 2016).

4.3.3 Plan, Design & Construct (PDC)

The third existing Dutch procedure resembling ECI is the PDC procedure. This procedure is a variation on the D&C contracts. In PDC projects the contractor is contracted whilst the project initiation phase is not completed yet. This is earlier than in D&C projects, where procurement is finished when the project orientation is finished. PDC looks like the 'interweaving Model 3' in figure 9. The first implementation of PDC was in the Nederrijn project, as part of the Dutch *"Ruimte voor de rivier"* project (Rijkswaterstaat, 2014). The procedure based the procurement on the principles from *Best Value Procurement* (BVP). This selection process helps to select a contractor with emphasis on criteria other than price, as the price in such an early stage of the project is difficult to determine. The goal of PDC procedure is to exploit the creativity of the contractor in addition to benefits on costs and time. The only current big PDC project is the refurbishment Hoevelaken highway junction. There are several smaller PDC projects executed in the Netherlands by the Water Boards, but there is no literature available on these projects or the PDC principle in general.

4.4 Advantages-, Disadvantages- and Barriers of ECI

This subchapter focusses on the advantages and disadvantages of ECI. As several interpretations of ECI and their resulting procedures are discussed above, the intention was to differentiate between the different approaches and name the advantages and disadvantages accordingly. However, the ambiguity of ECI in literature resulted in the benefits and disadvantages of ECI being used seemingly interchangeably. Distinctions are made whenever possible.

4.4.1 Advantages of ECI

The advantages of ECI which are discussed up to here are listed below. The advantages are elaborated on shortly by the leading corresponding sources used in this thesis.

- **Quicker project delivery** (Bundgaard et al., 2011; Leendertse et al., 2012; Lenferink et al., 2012; Love et al., 2014; Rahmani et al., 2013; Song et al., 2009; van Valkenburg et al., 2008). Most sources state that ECI helps in delivering a project more quickly. By introducing the contractor earlier in the process, continuous collaborative advantages pay off the most. This non-exclusively includes factors like less conflicts and better risk distribution. Especially the expertise of the contractor in technical aspects and costing is said to speed up the designing and construction of the project. There is no distinction made in any form of ECI performing better than any other, and all sources state quicker project delivery as the primary advantage.
- **Cost reduction** (Bundgaard et al., 2011; Leendertse et al., 2012; Lenferink et al., 2012; Love et al., 2014; Rahmani et al., 2013; Spang, 2012; van Valkenburg et al., 2008). In addition to the reduced delivery time of a project, general cost reduction of the works is also a common benefit named in literature. The connection between costs and delivery time does seem to play a role here, but there are other aspects named to yield a reduction in costs as well. The expertise of the contractor in the costs of materials, ways of executing certain techniques and agreements with their suppliers all benefit a reduction of costs in the end. Most literature acknowledges that increased investment in the early phases is necessary to incentivize the contractor in joining the process earlier. Other literature (especially on design team as ECI)

states that the incentive of the increased chance of getting the construction contract may be incentive enough for the contractor to join early.

- **Higher certainty in costs and planning** (Love et al., 2014; Rahmani et al., 2013; Spang, 2012). As the contractor is the expert on the costs and execution of the works, he knows best where the risks lie in construction. The contractor can use this expertise early on to help assess and mitigate risks. This is said to result in better accuracy and certainty in costs and planning early in the project.
- **Improved quality of design and project** (Leendertse et al., 2012; Lenferink et al., 2012; Rahmani et al., 2013; Spang, 2012; van Valkenburg et al., 2008). As aforementioned, the contractors' expertise can contribute to design in ways the designers are said to miss. This may include knowledge of (possible) innovations, construction techniques and materials. In addition to the discussed expertise, the benefits in project quality are also said to come from the improved collaboration. Because the collaboration starts earlier and teamworking benefits increase during the duration of the project, it follows logically that ECI increases these benefits.
- **Improved innovativeness** (Bundgaard et al., 2011; Knutsson & Thomasson, 2014; Spang, 2012). As contractors are more aware of the innovations in the techniques and materials they use and develop, the increased space and involvement of the contractor makes implementation of these innovations easier. It is hard to pin down what these innovations may entail, but the increased space and involvement is often mentioned to improve the innovativeness of construction projects.
- **Improved risk distribution and management** (Bundgaard et al., 2011; Chao-Duivis et al., 2013; de Koning, 2018; Koenen & van de Pol, 2015; Rijkswaterstaat, 2009). A distinction can be made for different ECI interpretations here. When considering interweaving, Rijkswaterstaat states that proper distribution of the risks is one of the success factors of the approach. The collaborative approach to identify the risks and distribute them to the best suited carrier for the risk implies that there is less risk on the contractor than in traditional contracts. With a design team, the collaborative effort in the design phase helps to improve risk identification. In sources discussing ECI in general, improved risk distribution and management is named as a benefit to ECI but not underpinned further than the explanations given above.

4.4.2 Disadvantages of ECI

The disadvantages to ECI are not often discussed. In contrast to the benefits, very little literature covers the disadvantages to ECI.

- **Inexperience with ECI** (Davis et al., 2008; Love et al., 2014; Wondimu, Hosseini, et al., 2016). One of the disadvantages of ECI recognized in Australia is the inexperience with the process both by public and private parties. This is confirmed in Norway as well, where the public parties seem to lack either experience, initiative, or both to experiment with ECI (Wondimu, Hosseini, et al., 2016). Because parties are inexperienced with ECI, they seem to experience difficulty with reaching the potential of the concept or even any benefits at all (Love et al., 2008; Wondimu, Hosseini, et al., 2016). As this is better viewed as a barrier to successful implementation, this will be elaborated more on in the next section.
- **Insufficient incentives** (Chao-Duivis, 2012; Mosey, 2009). As ECI involves contractors earlier in the process, they require either an incentive or compensation for their work. In the Netherlands, the incentive for the contractor is the advantageous position for getting the construction contract (Chao-Duivis, 2012). In the UK, the contractor is paid a consultancy fee for the work on the design (Mosey, 2009). It is unclear on what basis the contractors are compensated for the extra effort from literature in other countries or with other forms of ECI. The guess is that there is at least a compensating measure available for a contractor which

helps with the design but is not awarded construction. In comparison to traditional methods, ECI will cost the client extra initially. Extra costs can be considered a disadvantage of ECI, as these are guaranteed, and the benefits are not.

Concluding this short discussion on the disadvantages, it becomes clear that too little experience with ECI gives an unbalanced picture of the principle. The benefits are said to be many, but very little proof of this can be found in literature. Following this, it seems logical that few disadvantages of ECI are discovered and documented as such so far.

4.4.3 Barriers to implementing ECI

As shortly introduced above, there may be barriers obstructing the implementation of ECI (Love et al., 2008; Song et al., 2009; Wondimu, Hailemichael, et al., 2016). Song et al (2009) state that the benefits of ECI are only likely to be achieved when ECI is embedded in practice. This requires contracting to become familiar with ECI, involved parties to be ready for the kind of teamwork it requires and, maybe most importantly, the culture in the construction sector must change. Better understanding of the concept of ECI and its implications are necessary to facilitate this culture change (Song et al., 2009). From the experiences in Australia, it becomes clear that especially public entities need to help push the principle (Davis et al., 2008; Love et al., 2014). These entities are embedded in their existing ways of working, and this holds innovation back. In Australia, traditional lump sum contracts are still the go-to contract types, stifling the implementation of ECI there (Love et al., 2014). Love et al (2014) state that improvement is coming, but it is still going very slowly. Trust in the construction sector is an important aspect for this cultural change. Trust is named as a success factor for ECI, but trust is not yet naturally present in (the Dutch) construction market. Especially after the building fraud, trust has been damaged (Boes & Dorée, 2013). Regaining trust between parties in the construction sector is considered an important aspect to facilitate the required culture change for successful adoption of ECI.

In Norway, research into the implementation of ECI found several success factors and corresponding barriers. Interviews with key actors in the construction sector there showed that ECI is considered demanding for the involved parties (Wondimu, Hailemichael, et al., 2016; Wondimu, Hosseini, et al., 2016). Even though ECI allows more responsibilities to the contractor, the contractor should be able to expect the client to know what he or she wants. Another barrier identified by Wondimu et al (2016) is that proper compensation needs to be in order. The interest and enthusiasm to participate in ECI projects relies heavily on the form of compensation. Effective implementation can only be achieved when fitting compensation for the work is promised and given (Wondimu, Hailemichael, et al., 2016). When the client is clear on what is requested of the contractor, the contractor must also be willing and able to provide this early on in the project (Love et al., 2014; Wondimu, Hailemichael, et al., 2016). As the client may ask more of the contractor than the contractor is used to, the contractor may be expected to step up and make sure the wishes of the client are met even when they are untraditional (Wondimu, Hailemichael, et al., 2016).

The identified barriers show that primarily a culture change is needed for ECI to be effectively implemented. When the culture in the construction sector changes to a more ECI appreciative view, additional experience with the concept will be gained. This will result in improved collaboration and project outcome for all parties involved. Based on the identified barriers, a list of success factors for effective implementation of ECI is made by Wondimu et al. (2016):

1. Involve contractors early enough. Earlier involvement may yield higher benefits.
2. Make a manageable risk transfer to the contractors so that risk is distributed fairly.
3. Make both client and contractor aware of the required competences for either side and make sure these competences are met.

4. Award proper compensation for the contractor's contribution.
5. Fit the qualification criteria for contractor selection according to the ECI approach.
6. Increase trust between the contractor and the client.

4.5 Construction Projects in the Public Sector

This section contains the typical aspects of construction projects in the public sector. The project life cycle, project delivery methods and other aspects will be discussed. The goal of this section is to provide the theoretical basis for the scoping round. This basis will be formed to a system to construction projects in the scoping round chapter.

4.5.1 Characteristics of Public Projects

The construction projects in the public sector have the distinction that the client is a public entity. This means that every project is subject to public regulation and legislation. There are exceptions, but these are not relevant for this research. To get an idea of the sort of construction projects that are built in the public domain, see Table 4 (Boyd & Chinyio, 2006).

Table 5: Typical construction projects for public clients

Construction Projects from Public Clients	
Local	**National**
Schools	Defence
Social Services	Government
Leisure	Highways
Police	Environment
Waste	Prisons
Transport	Courts
Public Administration	Taxation
Fire	Intelligence
Roads	Regulations
Libraries	
Health	
Housing	

The general principles of public procurement which apply to construction projects state that the process has to be transparent, fair and competitive (de Ridder, 2009). These principles are reflected in the EU directives for public procurement (Kamminga, 2012):

- The equality principle (equal treatment of all tenderers).
- The transparency principle (demands and criteria have to be made public before tendering starts, including their motivation, to show how the tenders are tested and ranked).
- The non-discrimination principle (there is no difference in treatment of tenderers of different nationalities).
- The objectivity principle (the performance of the procuring party has to be objective and controllable).
- The proportionality principle (there are proportionality demands for the tenderers available, to test the fit of the tenderer for the size and form of the assignment).

These principles must be adhered to in the procurement of public works. They may also apply to private works, if the threshold of project value exceeds €5.548.000 (European Union, 2014; Pianoo,

2018). In addition to the regulation considering procurement of the projects, there are some more particularities concerning public construction projects. As public entities are viewed different in legislation, the relation between the client and the designer and/or contractor may be slightly different from private construction projects. Projects in the private sector tend to have more relational aspects in their execution, whilst public projects have to be transparent and encourage competition (Boes & Dorée, 2013).

4.5.2 Construction Project Characteristics

For application of systems thinking it is important to research the general construction project aspects and characteristics. This section discusses the project life cycle and the terminology concerned with construction projects.

The project life cycle for construction projects consists traditionally of 5 phases, see figure 10 below:

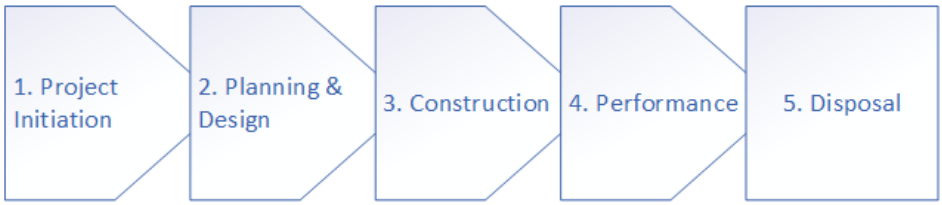


Figure 10: Project life cycle

It is important for this research to specify in more detail when de contractor can be involved when using ECI. Therefore, the 10 phases in the project life cycle as identified by de Ridder (2009) are used. These are shown as a more detailed specification of the traditional model in table 5. Because ECI focusses primarily on the first three phases, the *Project Initiation phase,* the *Planning & Design phase* and the *Construction* phase are focused on in this study. The *Performance*- and *Disposal* phase are not further discussed.

Table 6: Detailed project life-cycle

Construction Project Life Cycle	
1. Project Initiation	1. Project Orientation
	2. Feasibility Study
2. Project Planning and Design	3. Conceptual Design
	4. Prelimenary Design
	5. Detailed Design
3. Construction	6. Preperation and Construction
	7. Installation and Finish
4. Performance/use	8. Testing
	9. Operation
5. Disposal	10. Demolition

When considering interweaving as an ECI procedure as described above, the environmental impact assessment (EIA) procedure is incorporated with the project planning and design phase. When these are not interweaved, these procedures split and run parallel to each other (van Valkenburg et al., 2008). Completion of both the design process and the EIA procedure are required to start construction.

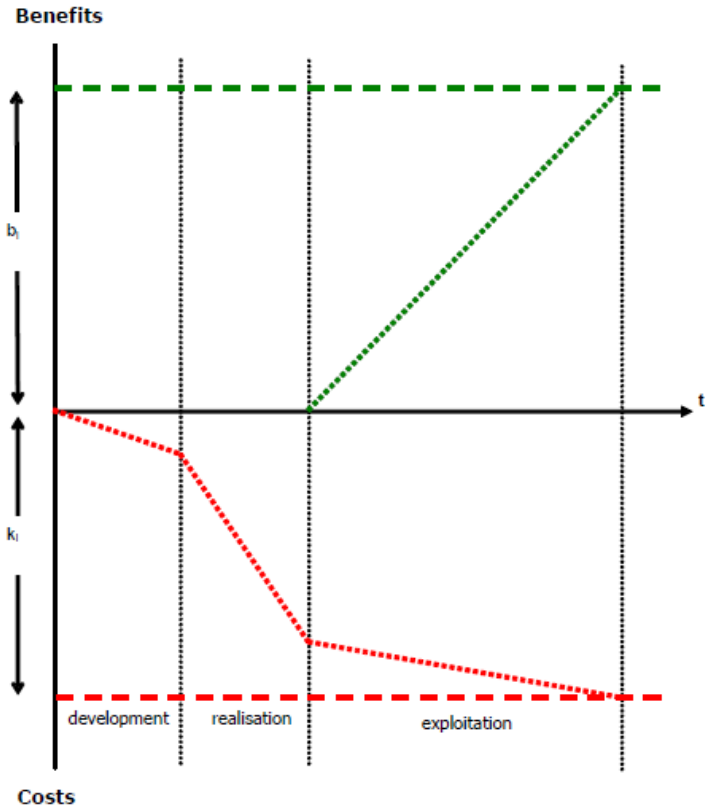


Figure 11: Costs & Benefits of projects over time (de Ridder, 2009)

The costs of a construction project are accumulated throughout the project lifecycle. The relation between time, costs and benefits can be represented graphically (figure 11; (de Ridder, 2009) The costs are shown in red, whilst the benefits are shown in green. This curve shows that most costs in a construction project are made in the construction phase of a project, whilst less costs are made in the development and exploitation phases. It is interesting to add the relation between the cost of changes and the duration of the project. As the project progresses, the cost of changes increases drastically and

the ability to change things in the project diminishes. This is shown in figure 12; note that the phases are named slightly different, but they show the same phases as described above. It is important to realize that ECI uses these relations of the cost of changes over time as a result of the decreasing flexibility in the design. By involving the contractor earlier, the cost of changes is still low, and changes can still easily be made. This underpins the benefit of cost reduction as a primary benefit to ECI.

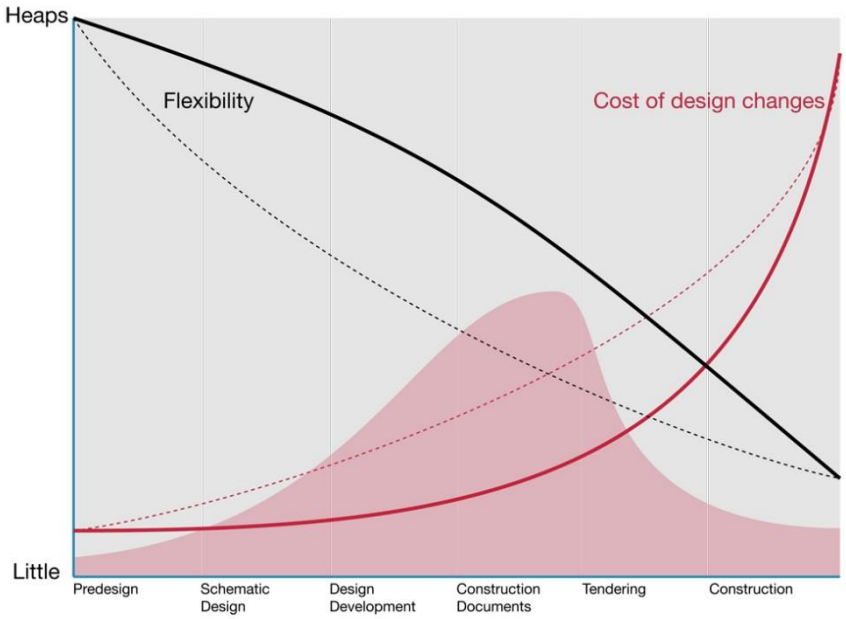


Figure 12: Cost of design changes and decreasing flexibility in construction projects (retrieved from http://www.danieldavis.com/macleamy/)

4.5.3 Strategic Behavior

The construction sector in the Netherlands suffered a large scale building fraud after the turn of the century (Meeus & Schoorl, 2004). Trust after this incident had been severely damaged and any hint of collusion was avoided in public construction afterwards (Boes & Dorée, 2013). The focus became on more and more competition in the building sector, to ensure the best (lowest) price for the project. The market seems to have recovered from this excessive focus on competition over collaboration, but others say traces from the distrust resulting from the building fraud are still visible (Boes & Dorée, 2013). Research on the interaction between client, authority and contractor in a simulation shows that when strategic behavior for gain is not carefully assessed, parties will use strategic or opportunistic behavior to improve their performance possibly at the cost of the other involved parties (Altamirano & de Jong, 2009). This may partially explain why the building fraud happened and why trust is hard to come by in the construction sector. Therefore, it is deemed important for this study to take strategic behavior into account when considering ECI, as the advantages of ECI may come at the cost of control in the project.

5. Scoping Round

The scoping round for the Delphi study helps to set definitions and raise the efficiency of the Delphi study (Donohoe & Needham, 2009; Powell, 2003). During the scoping round of the Delphi study, experts are consulted. The scoping round of aims at providing the link between the literature study and the Delphi interviews. This link is formed by:

1. Setting clear and unambiguous definitions, which are already implemented in writing the report. The list of definitions can be found on page vi.
2. Providing a clear and structured description of construction projects with the use of a system. These feature the relations between the three perspectives (client, contractor and designer/engineer) and a detailed view at the project life cycle.
3. Assessing the different perspectives on ECI on a conceptual level.

The final section of this chapter reviews the expert panel used in the Delphi panel. As explained in the *Methodology* chapter, the selection of the experts is the most important part of the Delphi study.

5.1 Expert input for the Scoping Round

Consulting the experts mentioned above proved that there is a lot of ambiguity of what ECI is. The terminology used to describe ECI varied a lot. The experts were mostly in agreement that for the goal of this research, the most abstract, high-level definition for ECI was the best starting point. Therefore, the definition for ECI is kept at "*involving a contractor in the planning phase*". The consulted experts in the scoping round pointed out that there may be significant differences between the theory and the opinions of the expert panel. For the first round it is important to extract the definitions of ECI of the experts in the panel. If they are unable to formulate a definition, the principle definition is given, with the suggestion of contract types like Design teams, interweaving or a form of a Design and Construct. This choice aims at providing structure for the further answers of the interviews.

The proclaimed benefits for ECI are recognized by the consulted experts in the scoping round, but it seems hard to pin down which benefits are gained for different ways of implementing ECI. The benefits for ECI are defined in such a generic way that only deduction seems to link certain benefits to different practices. An example would be that Interweaving leads to more innovation as the contractor can help with the procedural designs for the required permits, but only when involved early enough to really make a difference. The consulted experts agree that ECI has the potential to achieve the mentioned benefits in literature, but only when the process is designed and implemented to facilitate this. The experts specifically stated that the flexibility of procurement regulation is not used optimally or properly regarding design teams as ECI.

The experts pointed out that Sweden is following the 2-phase model in a similar way as it is used in the UK. As implementation of ECI is still recent, research is currently done in Sweden on the desired form and benefits for construction projects there. The experts stated that the Dutch Design Team should be viewed as ECI. The Design Team has been improperly used and has come under scrutiny in the construction fraud in the Netherlands. But, if used properly, the experts state that the Design Team can facilitate everything associated with ECI.

The discussions with the experts gave a deeper understanding of the procedures, customs and practices in public construction projects. As this knowledge is mostly tacit, it suffices to mention the expertise of the researcher on the subject was increased by the scoping round, which improved the quality of the interviews.

5.2 Defining the Theoretical Framework

The theoretical framework consists of two parts. First, an assessment of construction projects, using systems thinking. This is followed by considering the playing field between the client, contractor and designer.

5.2.1 Applying the System Approach to Construction Projects

Based on the method and goal of systems thinking from earlier, a construction project must be defined within the boundaries of systems thinking. The focus here is on the elements and interconnections of the factors that make up the construction project. The system approach simplifies reality greatly to gain understanding. In addition to this simplification there is another important aspect to the use of systems thinking in this paper. Construction projects tend to be organized in different ways according to different project delivery models and contract types. As ECI is not defined as such, a system must fit all construction projects regardless of contract type or delivery model. The life cycle system only takes the phases into account leading up to the handover of the project. This is based on the assumption that ECI impacts these three phases directly, whilst only indirectly affecting the Performance and Disposal phase.

Building the model of the construction project system first required identification of the elements. These elements are derived from a sparring session with colleagues and validation by Sander Jacobs of RHDHV. The next step is to identify the connections between these factors. The connection and relations are visualized as a generic view on construction projects. These visualizations and their explanations can be found in Appendix A. To clarify the workings of the systems organized by the life cycle phases, the relations and elements are aggregated into a simplified life cycle system. This can be found in figure 13.

The aggregated system in figure 13 shows the grouped elements (from now on called ‘groups’) for most construction projects, organized on closest relations and timing. The figure shows the elements in the groups as actions in the parts of the project. The orange circles state the intended result upon completion of the elements in the group. The arrows show the relations between the groups. There are two important things to note in this figure. The first is that there is a feedback loop between the project orientation group and the feasibility group. This represents the incremental changes made on several project aspects during the feasibility study and then being implemented in the feasibility study. The second is the positioning of the 4th and 5th group, Procurement and Contract Negotiations; as the procurement of a project depends greatly on the project strategy and the project description resulting from the (almost) completed feasibility study, the position of the Procurement group suggests that the procurement of the project can either start in the 1st (Project Initiation)- or 2nd (Design and Planning) phase. The Project Negotiations follow directly after that and may flow over in the next phase, but this is generally not the case. When ECI is fit on the system in figure 13, ECI would mean that the contractor is involved at the end of group 2; the Feasibility Study. The hypothesis is that ECI would use group 4 & 5 in the Project Initiation phase, in parallel with group 2. The client will have to make the decisions in group 3 earlier than is currently the practice. The contractor whom emerged as winner from the tender procedure can use his expertise to improve the design on practicability and tailor the project to fit his expertise. If this is done early enough, it may still be possible for the contractor to influence the Feasibility Study and elements of the Project Orientation before decisions are made final. As a result, the early input from the contractor’s expertise could make the further project execution more efficient. This implies quicker project delivery, a decrease in costs and a finalized project of higher quality.

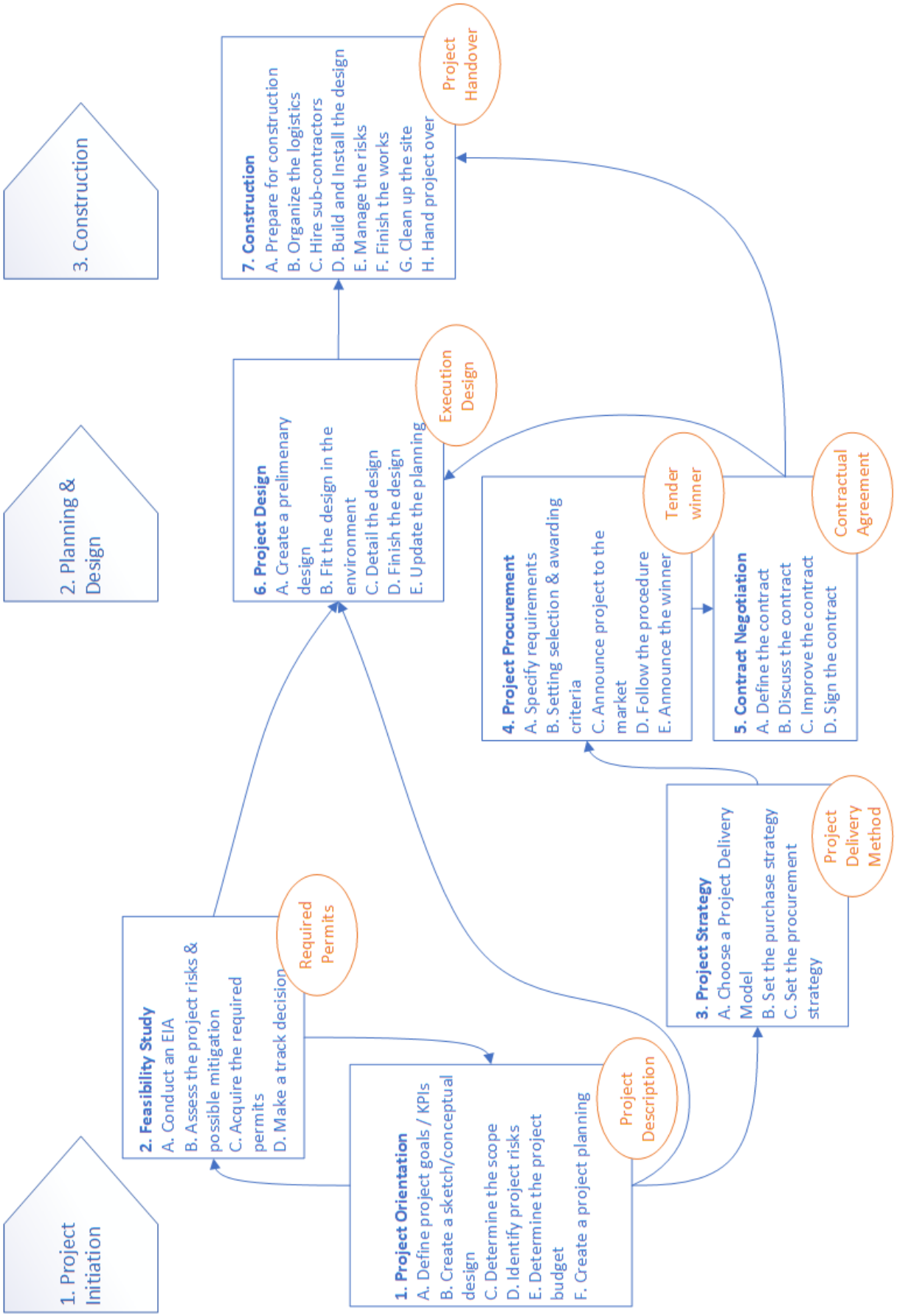


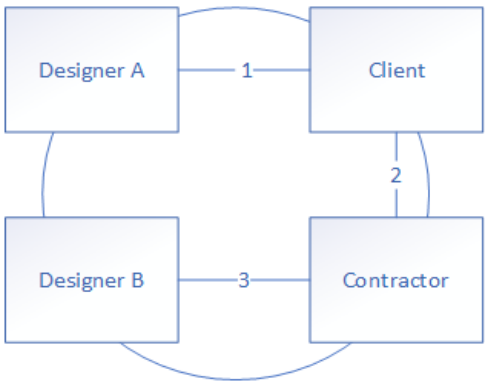
Figure 13: Construction Project System as theoretical framework

Any system is a simplification of the real world. As described in the *Methodology* chapter, the purpose of the system is to understand construction projects and to allow unambiguous discussion on ECI. Based on this purpose and system thinking characteristics, it is important to note several things:

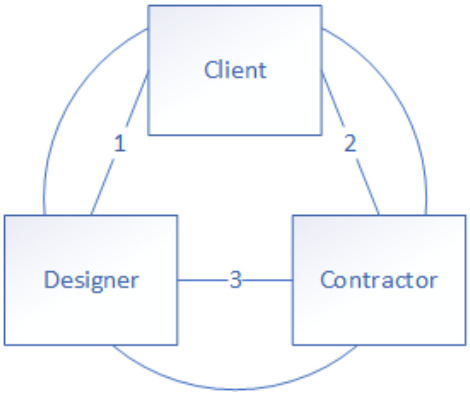
- The system is designed to fit most construction projects. This implies that there are projects that are organized differently than the system suggests. When conflicts were found between different project delivery models, the choice was made to design the system in such a way that most definitions of ECI would fit.
- Even though the figure is structured according to the life cycle phases perspective, the detailed life cycle as discussed by de Ridder (2009) are taken into account. The first two are represented as the first two groups. The three design phases[9] are incorporated in the Design group. The two phases[10] for construction are both part of the Construction group.

5.2.2 Assessing the Playing Field

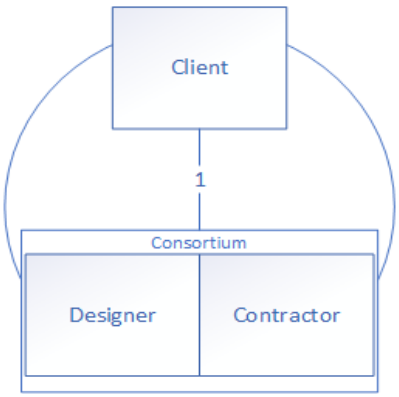
From the literature study it became clear that ECI may require a culture change in the construction market. As stated in chapter 2 *Research Approach*, effective implementation of ECI requires the vision of the parties directly affected by ECI from their perspectives. To connect with these perspectives, a short review of their mutual relations is done. The relations between public client, contractor and designer are visualized in figure 14. These figures are based on discussions during the scoping round and fit in the system of figure 13. The starting point for this form of collaboration is at either the *planning & design* or *construction* phase. 14B can start at any point the client chooses to. Both figures 14C & 14D are most likely to start during the end of the *feasibility study* phase.



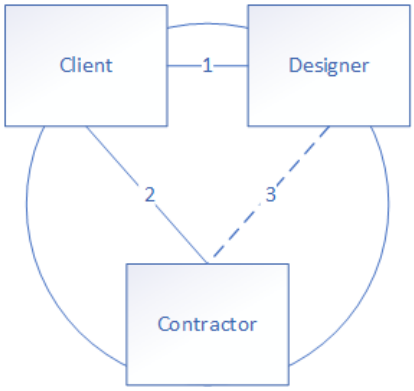
A. Traditional or D&C



B. Design Team



C. Possible PDC or ECI



D. Possibility for ECI

Figure 14: Construction Project Relation Concepts

[9] Conceptual Design, Preliminary Design and Detailed Design
[10] Preparation and Construction; and Installation and Finish

Depending on the project strategy pursued by the client, the relations between the client, contractor and designer are formed. The most left figure (figure 14A) represents the relations in an either traditional or D&C setting. When looking at the figure from a traditional perspective, the client hires a designer to provide expertise the client may not possess or have available to initiate the project (relation 1). This is typically done by advising the client on different design solutions and possibly designing the solutions themselves. When the design is finished, the client hires a contractor who will construct the project, possibly with design support of a different designer (relation 3). From a D&C perspective, the client is still likely to hire a designer to initiate and prepare a project. When the early designs are finished, the contractor is hired to detail the design and construct the project. As the core business of a contractor is constructing, not designing, the contractor may hire extra design capacity from a designing firm.

Figure 14B shows the relations in a design team. Relations 1 & 2 are contractual relations with the client in addition to the coordination agreement on which the design team functions (relations 1,2,3). As the design team relies on the input all the parties give, the design team is a very intense form of cooperation. This is most likely felt most by the client.

Figure 14C shows the most likely relations in the PDC contract type. The contractor and designer enter a consortium, which is awarded the contract from the client. When considering ECI, these relations may shift. One hypothesis is that designers and contractors cooperate more closely, possibly in the form of a consortium, like in figure 14C. The PDC form is aimed on the design. Another option is that the designer will take on a more representative role for the client, acting on his behalf (visualized in figure 14D). This form is less collaborative than the PDC form, as the client has more distance to the contractor than the form described in figure 14D.

The relations described above are mainly contractual. The collaborative relations can also be explained by reviewing the alignment of the goals and interests of the different actors. This also helps to explain possible strategic behavior of the actors.

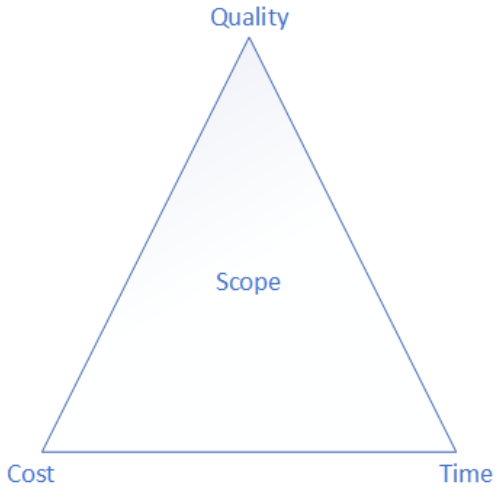


Figure 15: The Iron Triangle

Public clients start a project with a specific goal in mind. This varies between new parts of highway or railway, hospitals or schools. As they finance these projects with tax-payers money, they have a responsibility to show the money is well spend. Bad investments or project execution has political consequences, possibly with reduced budgets for the corresponding clients. Reflecting this to the *iron*

triangle of project management (see figure 15), their focus is assumed to be on quality and time. Cost is not considered to be the focal point, as the client generally is willing to pay a fair price for the project.

Designers are assumed to be quality oriented. As they are contracted by either client or contractor, they work on a time-dependent fee. They are not necessarily contracted through procurement procedures but assumed to be contracted more through relations. Future contracts are therefore dependent on the quality of work they deliver. The core business of designers is drawing, engineering and detailing the designs for projects. Implementation of ECI could decrease their work on this, as more may be done by the contractor.

For the contractor costs are most important. Their profits depend on the margins they gain from the contracts. Depending on the contract, this may shift slightly, but cost will also be the primary driver for contractors. When a contractor is introduced to the project earlier, he is assumed to have a higher chance on a rewarding contract in exchange for an increased investment in the early phases of the project. According to the experts in the scoping round, the compensation for a contractor who contributed in the early phases (either in a design team or in the dialogue during the procurement) is very often less than the investment the contractor must make. Depending on the way ECI is implemented, the contractor could be tempted in making this investment, but the risk and reward will be considered carefully.

The difference in interests and focal points for construction projects already creates tension in the relations of the actors. Introducing ECI to this adds the difficulty of a new form of collaboration. Even though ECI looks great in literature, the practical implications may not be hailed as positive or realistic by the actors in different perspectives.

In conclusion, the scoping round provided insight in possible definitions of ECI and deepened the understanding of ECI from literature. In addition, the result of the system approach provided a framework to discuss ECI in construction projects. Based on the knowledge gained in this scoping round, the interview questions were created. These can be found in Appendix B.

6. Results of the Delphi Study

The results of the Delphi study are presented in this chapter. The presentation of the results is based on the three topics; the definition of ECI, the benefits and disadvantages, and the implementation of ECI. The formats of interview questions and questionnaires can be found in Appendices[11] B, C & D. The chapter concludes with the results of the confirmation session.

The panel size at the end of the interviews was 11 experts, as the 12th expert dropped out during the interview. All 11 of them responded to the first online questionnaire. During the second (and last) questionnaire, 9 experts responded. The attrition in the expert panel and the implications thereof are discussed in the chapter *Discussion*.

6.1 Defining ECI

The initial definition for ECI was set very broad. The definition was "*involving a contractor in the planning phase".* This way, the experts had a stepping stone to define ECI for themselves. As a reminder, the threshold for consensus was defined set at 75% in the *Methodology* chapter. A secondary threshold for weak consensus was set at 50%.

6.1.1 Definitions of ECI

Several definitions emerged in the interviews, mostly linked- or compared to existing forms of collaboration or contract types. An overview of the answers is shown in figure 16, below.

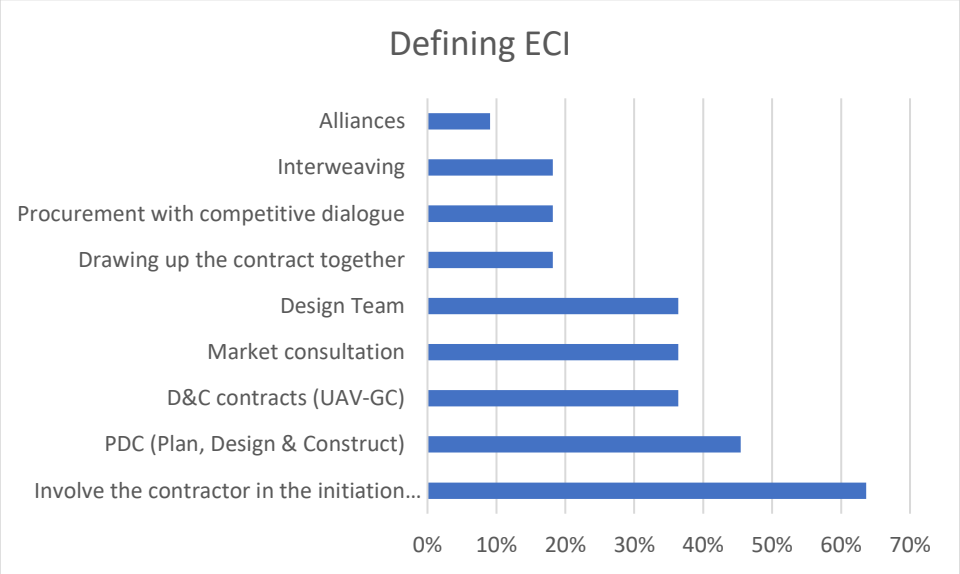


Figure 16: Definition for ECI from the interviews

The figure shows that none of the definitions carry consensus. The definitions given by the experts were so different in typology that the first questionnaire aimed at finding common ground for the definition of ECI, split for the different answer typologies. The panel agreed unanimously on the goal of ECI; *"Involving the expertise of the contractor".* None of the other suggested parts of the definition were carried by the panel.

The first questionnaire carried a question which suggested a definition for ECI based on the answer frequencies of the interviews. This definition, *"ECI is contracting a contractor in the initiation phase"*, was carried by approximately 55% of the panel. The experts opposing this definition stated clearly that

[11] The interviews and questionnaires are conducted in Dutch.

this definition was too narrow. According to these experts, ECI should include market consultations or a form of competitive dialogue.

In the second questionnaire a split was suggested to specify two forms of ECI, following the feedback on the first questionnaire. ECI was split between:

- A consulting form of ECI
- A contracting form of ECI

The definition of the consulting form of ECI carried a weak consensus of 55% for the Dutch *market consultation* ("Marktconsultatie"). For the contracting form of ECI, consensus was reached on contracting the contractor during the orientation phase with 77%. However, the question specified different stage-gates in the initiation phase connected to the track decision. No consensus was reached on the exact moment when ECI should take place, just that it should be 'during the initiation phase'.

6.1.2 Linking ECI to current practice[12]

Further specification of ECI lead to comparing ECI to existing forms of collaboration and contract types. The interviews aimed to identify the differences between ECI and current practices, but the spread in the answers revealed that the questionnaires had to clarify the similarities and distinctions. Figure 17 shows primarily the literal sense of ECI; involving the contractor earlier than is currently being done.

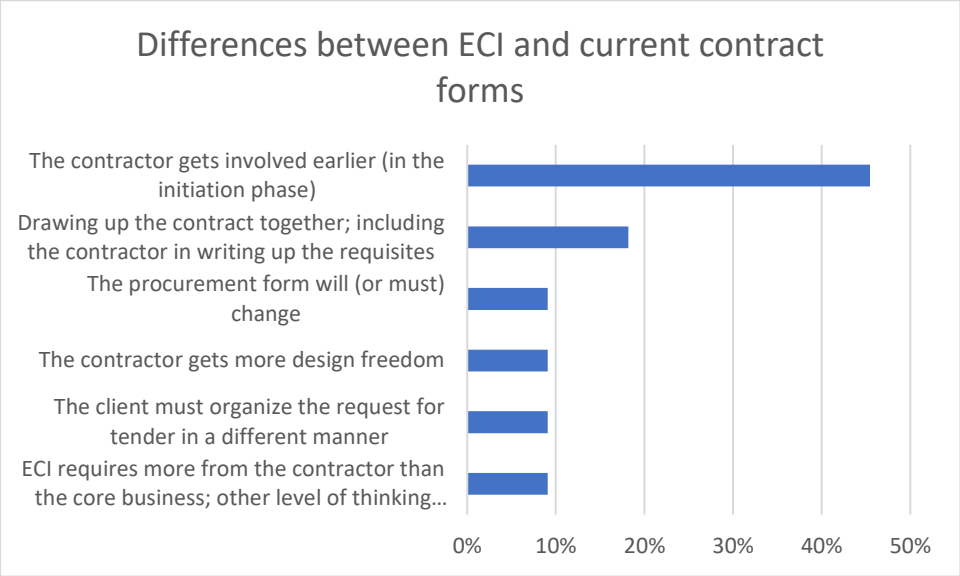


Figure 17: Comparing ECI to current practice

Questionnaire 1 looked into the expert's opinion on how ECI is currently used in the Netherlands. All experts agreed that ECI is already being used in the Netherlands one way or the other. However, 9 of the 11 consulted experts stated that the potential of ECI was not being reached. The other two stated that ECI might be used to its full potential already.

The way ECI is used in current practice was tested specifically in the first questionnaire. The following practices were viewed as using ECI:

- PDC's (82%)
- Interweaving (64%)
- Design Team (64%)

[12] Practice refers to both contract types and forms of collaboration here.

Other practices did not meet the 50% threshold. Following the reasoning that the potential of ECI was not being reached, the experts were asked if the existing practices would accommodate the potential of ECI or that a new contract type was needed. Weak consensus was reached stating that a new contract type is necessary to achieve ECI's potential.

The second questionnaire took a different approach in order to reveal the potential for ECI in current practice. When asked what forms of collaboration could accommodate ECI to reach it's potential, the following responses were given (shown in table 7, below)

Table 7: Could the potential of ECI be achieved in the following forms of collaboration?

	PDC	INTERWEAVING	DESIGN TEAM
YES	89%	78%	89%
MAYBE	0%	22%	11%
NO	11%	0%	0%

The experts were then asked to choose the collaborative form which could best exploit the benefits of ECI. The answers were *PDC* (56%), *Design Team* and *A new form of collaboration* (both 22%). These answers indicate that there are existing forms of collaboration to implement ECI to its potential, without requiring rigorous changes.

When linking ECI to the contract types that were mentioned by the expert panel that may be able to accommodate ECI, a more detailed result was found. The answers to the question *"Do you see a possibility to implement ECI in the following contract types?"* is shown in table 8, below.

Table 8: Would the implementation of ECI be a possibility in the following contract types?

	UAV-GC	UAV (TRADITIONAL)	NEW CONTRACT TYPE
YES	67%	33%	89%
YES, BUT WITH SMALL ADJUSTMENTS	33%	56%	0%
NO	0%	11%	11%

In summary, there are options to implement ECI in the current construction practice for the Netherlands already. The forms of collaboration that could use ECI which emerged during the interviews are all recognized to be able to implement ECI. The PDC form was selected most as the most promising alternative. The UAV-GC contract type may be able to accommodate the use of ECI, but possibly with some small changes to the legislation. However, a new contract type tailor-made for ECI may be even better.

6.2 The benefits and disadvantages to ECI

The benefits and disadvantages of ECI in public construction projects found in literature were not necessarily connected to a specified procedure for ECI. The aim of this part of the research was to identify and link the benefits and disadvantages of ECI to certain practices. As a reminder, the benefits and disadvantages from literature are summarized in table 9.

Table 9: Summarized benefits and disadvantages of ECI from literature

Benefits to ECI	Disadvantages to ECI
Quicker project delivery	Inexperience with ECI
Cost reduction	Insufficient Incentives
Higher certainty in costs and planning	
Improved quality of design and project	
Improved innovation	
Improved risk distribution and management	

6.2.1 The Benefits of ECI

During the interviews, the experts were asked what they thought to be the benefits that could be gained by their own definition of ECI. The benefits that emerged from the responses show many similarities with the benefits of ECI mentioned in literature, which can be seen in figure 18.

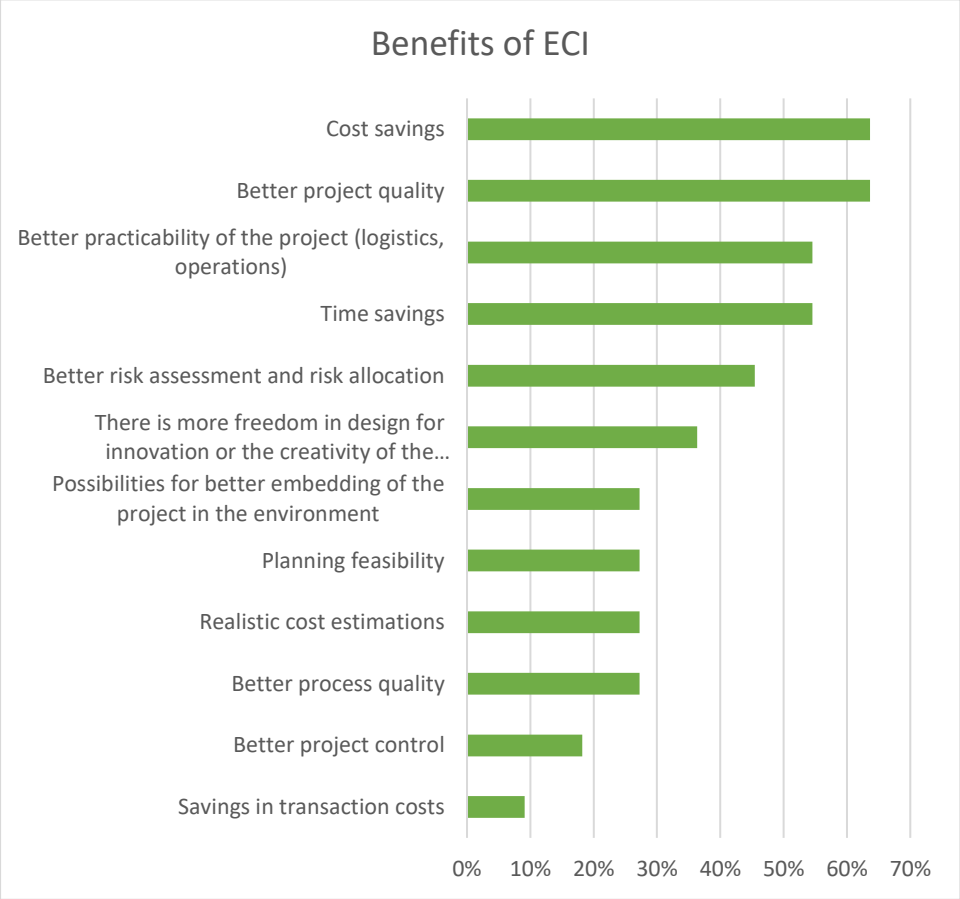


Figure 18: The benefits of ECI identified in the interviews

As the Delphi study entered the second round, it became clear that the limitation people had on their own definition for ECI required a revisit to all benefits and disadvantages. As the definition for ECI became more and more delineated, the experts could increasingly see the full picture sketched by the complete panel. The first questionnaire checked the expert's opinion on the entire list of the benefits mentioned in the interviews. The results are presented in figure 19.

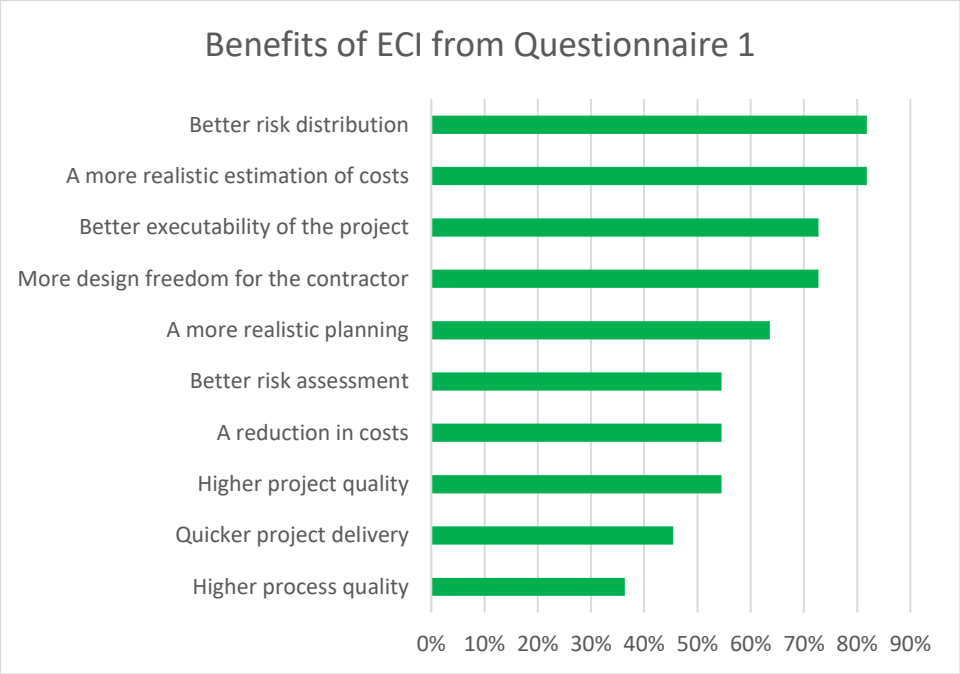


Figure 19: Benefits of ECI from Questionnaire 1

Figure 19 shows the benefits that were recognized by more than 50% of the panel. It is typical to see that the experts, upon confrontation with the benefits mentioned by others, recognized different benefits. Therefore, the next questionnaire elaborated further to find the cause of this. Questionnaire 2 first asked in what frequency the benefits would occur. It then asked to specify what benefits ECI could yield when compared to different forms of collaboration and contract types. As the recognition of the benefits in the first two rounds was inconsistent, all benefits named by more than one expert were tested again.

The expected frequencies of the benefits of ECI can be found in figure 20, on the next page. These are results from the third questionnaire. The results show a positive image where all named benefits are expected to be achievable with ECI, as the experts did not answer 'never' for any benefit. Figure 20 also shows that most of the benefits are recognized by more experts in the panel. However, the appearance frequencies do not follow the expected order in which the benefits were mentioned earlier. There are several possible reasons why this is the case:

- The experts all have a different set of circumstances, conditions and exceptions in mind, which influences the expected occurrence of these benefits greatly.
- Some are opponents, and some are proponents to ECI, which may have influenced their choices.
- The formulation of the questions was unclear to some or more.

Both the conclusions and implications of these benefits are discussed later, with the other aspects of the benefits found in this research, in the *Conclusions* chapter.

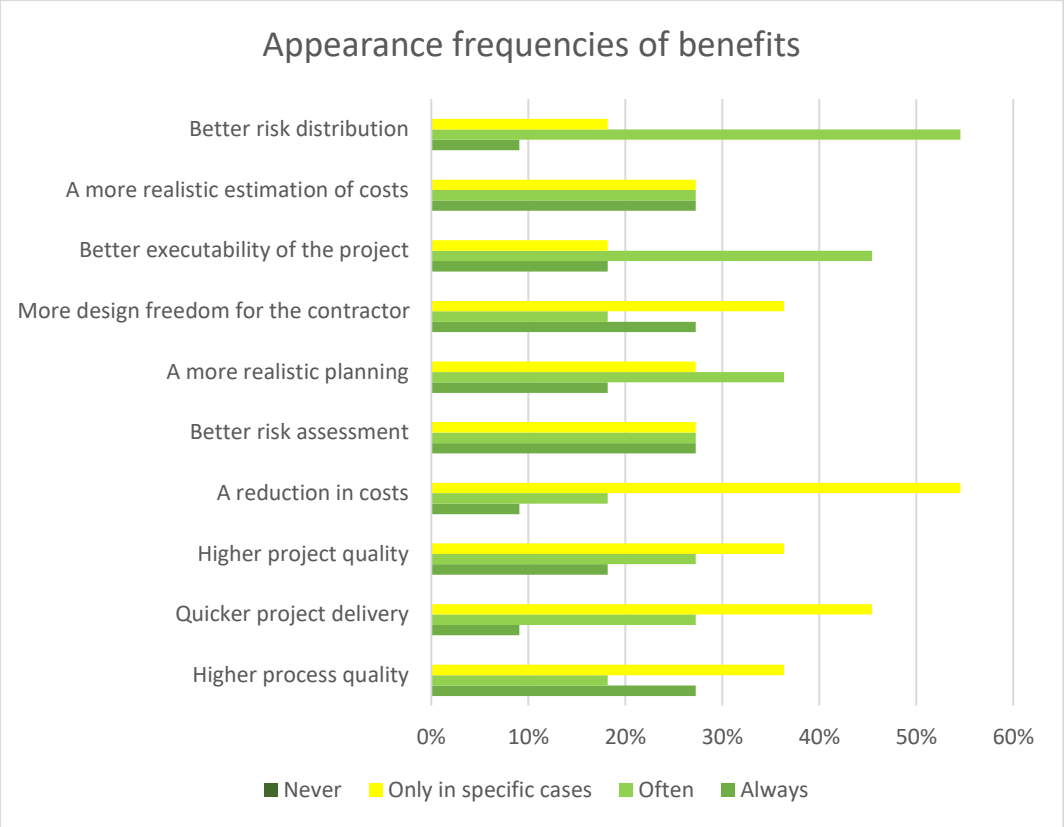


Figure 20: Appearance frequencies of benefits

Both online questionnaires had questions to further clarify the applicability of ECI. Questionnaire 1 tested this with the generic term 'complexity'. The panel responded with weak consensus (64%) that ECI yields more benefits for highly complex construction projects. Additionally, another 27% stated that ECI would yield benefits for construction projects, regardless of complexity. Further breakdown of this complexity was tested in the second questionnaire, which is discussed in the *Implementation* section of this chapter.

In addition to the general expected frequencies of the benefits of ECI occurring, Questionnaire 2 aimed at comparing these benefits to current forms of collaboration in construction projects. The results are combined in figure 21, on the next page. What stands out in this figure is that ECI has especially much to offer as an improvement to D&C projects. Without exception, all benefits identified earlier were found to yield most for D&C projects. The combined total of selections over the benefits was 58[13]. Only cost reductions did not reach the threshold, where all other benefits did. The 50% weak consensus threshold was not passed for any other benefit comparing to current practice. When looking at the form of collaboration that has the least to gain from ECI, the answer is clearly the design team. With only seven combined selections from the expert panel, it has very little to gain from ECI. The second

[13] For each benefit 9 selections were cast, with 10 benefits in the comparison. The maximum would have been a combined total of 90 selections.

least to gain from ECI are PDC projects. However, PDC has 18 combined selections over different benefits with none exceeding the weak consensus threshold.

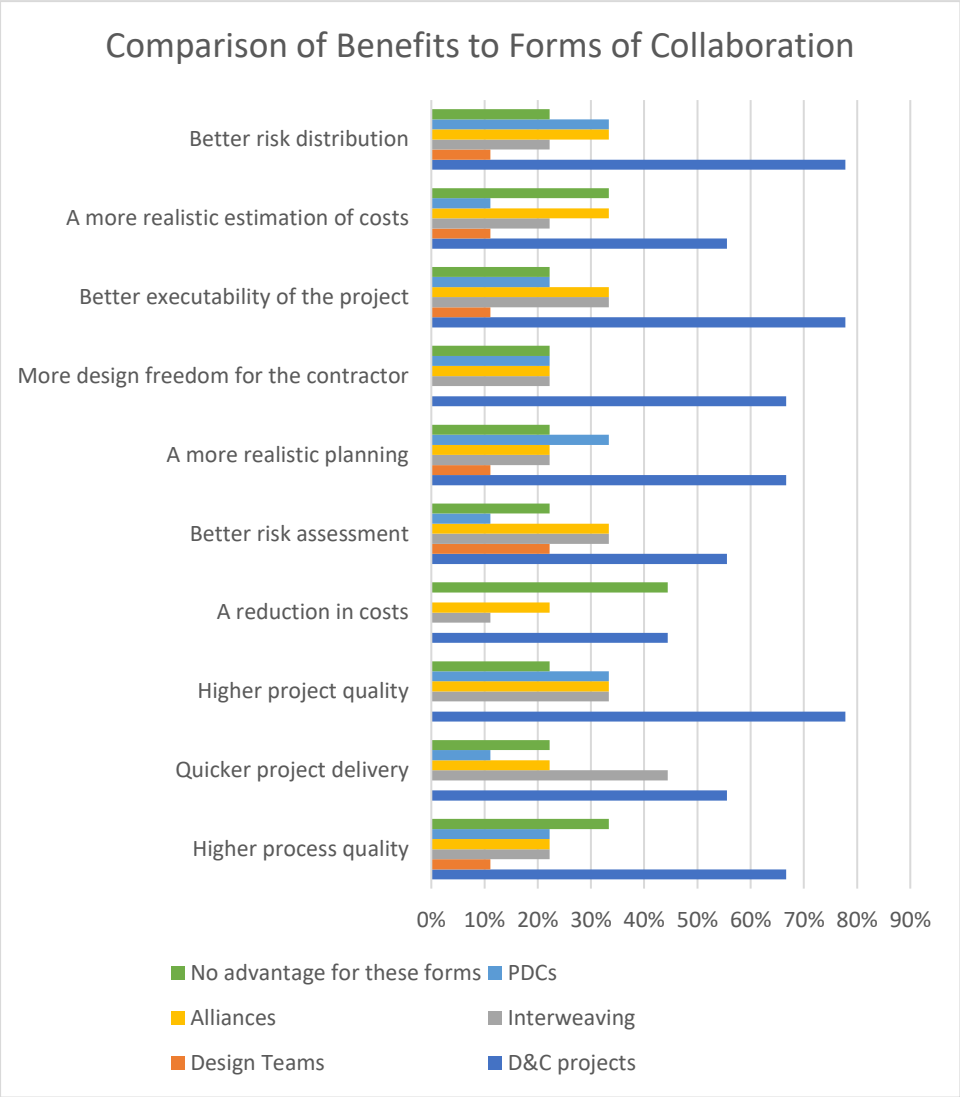


Figure 21:Comparison of ECI to other forms of collaboration

6.2.2 The Disadvantages of ECI

The disadvantages were assessed the same way the benefits were. The results from the interviews are shown in figure 22, on the next page. None of the disadvantages mentioned initially were carried by a majority of the panel or surpassed the 50% threshold. During the first questionnaire, all disadvantages mentioned more than once were questioned again. Figure 23 (also on the next page) shows the results of the first questionnaire. The only disadvantage surpassing the threshold of 50% in the questionnaire is the reduced flexibility for the client when a contractor is involved early. This is a different disadvantage receiving more selections than there were mentions in the interviews. The second most recognized disadvantage to ECI is the required level of thinking for ECI. Even though this disadvantage did not surpass the threshold, it has been a focal point for the second questionnaire. This is based on the assumption that the level of thinking really is important for ECI, which is the same reason the level of thinking was adopted as a criterion for the selection of the expert panel.

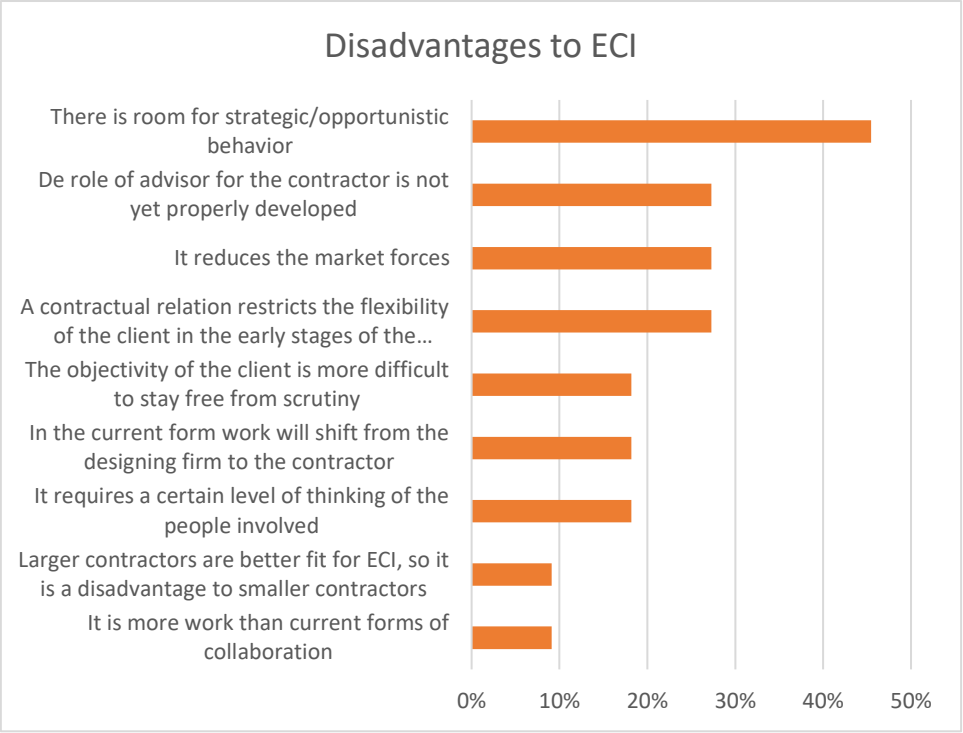


Figure 22: Disadvantages to ECI identified in the interviews

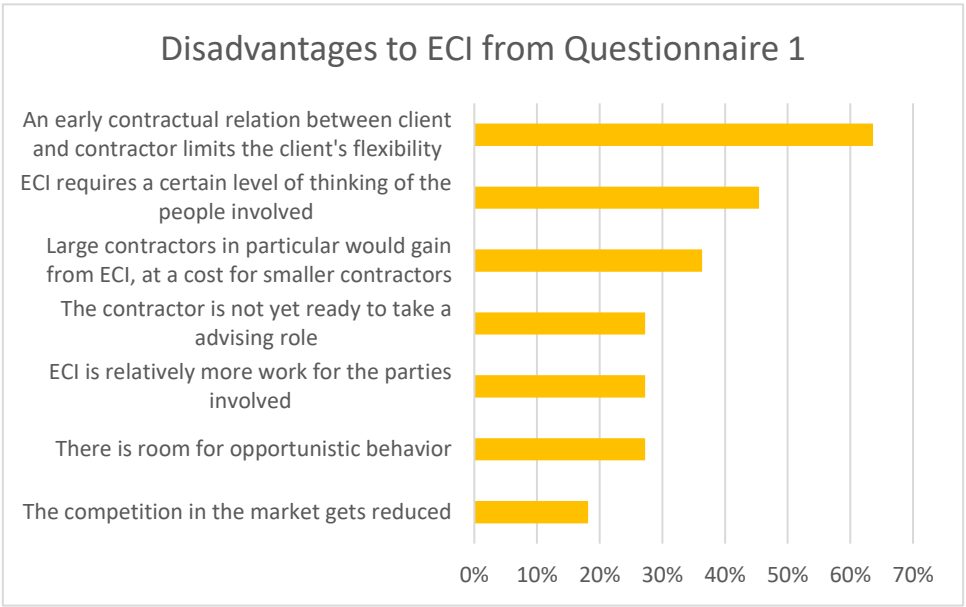


Figure 23: Disadvantages to ECI from Questionnaire 1

Questionnaire 2 assessed the assumed appearance frequency of the disadvantages the same way it was assessed for the benefits. The results are presented in figure 24, on the next page. Note here that the disadvantages are rephrased to better fit the question. The reduction in competition was taken out of the list, as this was found not to be problematic. In the interviews was already discussed that there are only a couple of contractors tendering for large projects, which is assumed not to change.

Upon the question if the disadvantages of ECI could be solved or mitigated, 45,5% answered “Yes”, 45,5% answered “Only partially” and only 1 expert answered “No”.

Figure 24 reveals that the disadvantages only seem to take place in specific cases. There are 4 disadvantages which exceeded the weak consensus threshold;

- The reduction in the flexibility of the client when using ECI.
- Loss of the benefits of ECI due an insufficient level of thinking.
- ECI is relatively more work for the parties involved.
- The extra room for strategic-/opportunistic behavior could cause problems.

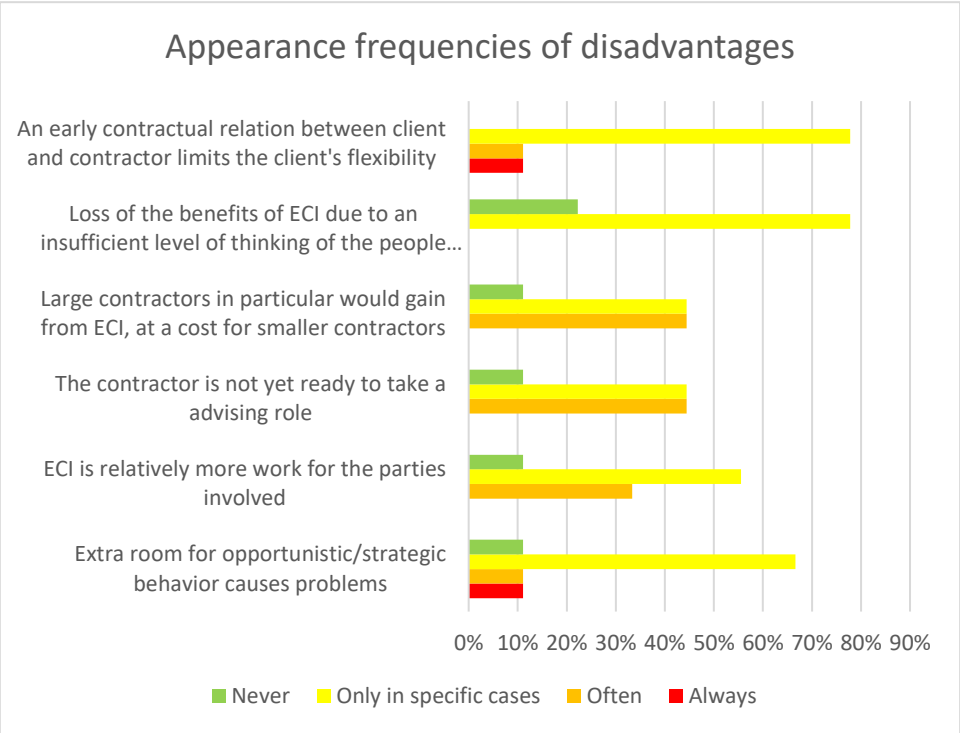


Figure 24: Appearance frequencies of the disadvantages of ECI

The link of the disadvantages of ECI compared to the current forms of collaboration is presented in figure 25, on the next page. This figure has no consensus on any of the comparisons. However, just like the benefits in comparison to the forms of collaboration, most disadvantages of ECI are found in comparison to D&C projects. The combined selections for this form is 16, which still is very low.

A question from questionnaire 1 may put the results above in perspective. On the question *"Do the potential benefits of ECI outweigh the potential disadvantages of ECI?"* 64% of the panel answered "Yes", whilst the rest (36%) chose "I don't dare to say". None said "No". Upon the option to explain the answer to this question, the experts who did, did not dare to say if the benefits outweighed the disadvantages gave conditions and requested for additional research and pilot projects to be done before they could give an answer.

In summary, the benefits and disadvantages of ECI show very little consensus in the results. However, the results do provide more insight on the benefits and disadvantages. When comparing the benefits from literature to the benefits from the Delphi study, a lot of overlap is discovered. When doing the same for the disadvantages, the Delphi study gives more and different disadvantages to ECI than literature did. Further discussion on this is done in the *Conclusion* and *Discussion* chapters.

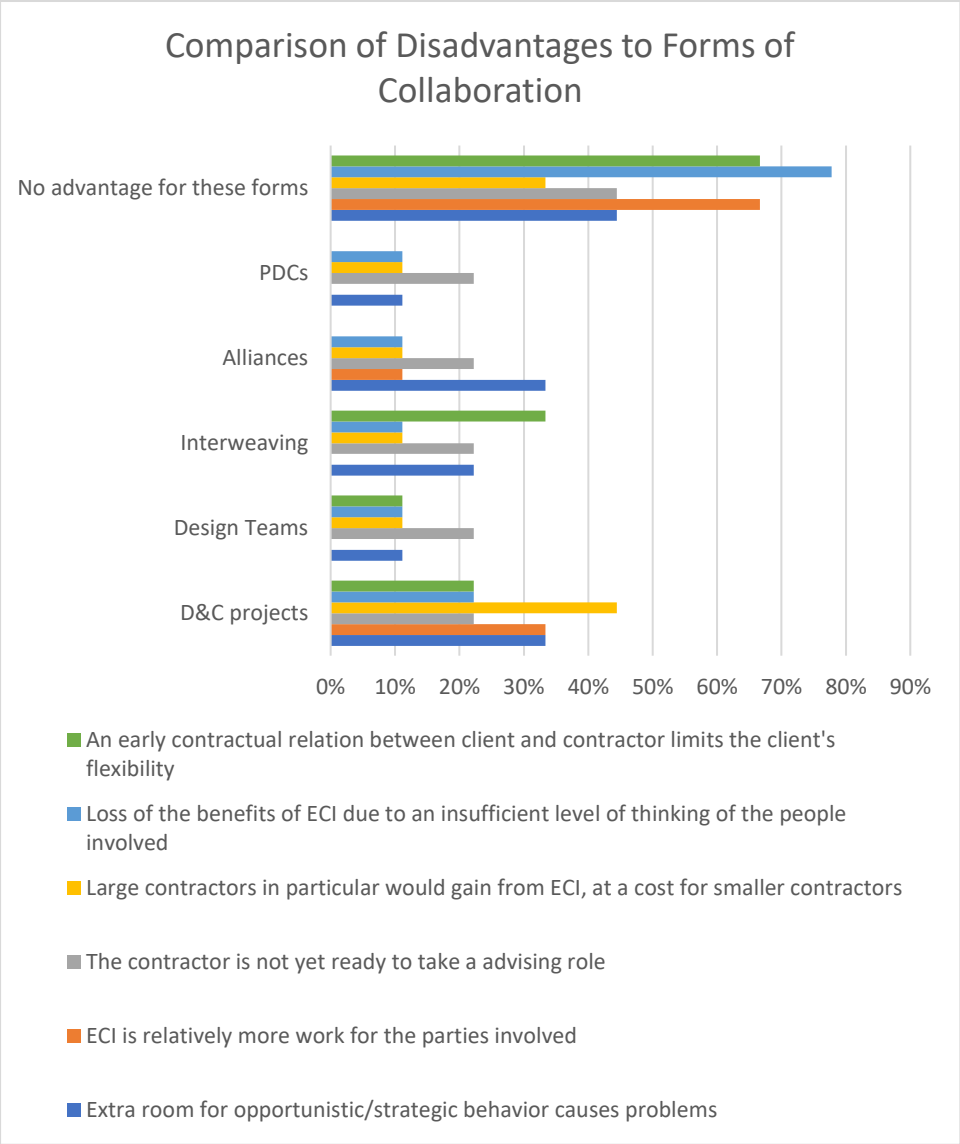


Figure 25: Comparison of Disadvantages to forms of collaboration

6.2.3 The Gains and Losses of ECI

The effects of the benefits and disadvantages discussed above were assumed to be different for the different parties involved. In the previous sections, ECI was discussed from the general perspective. In this section, the results are presented for the questions who would gain and who would not gain from ECI.

From the interviews became clear that the contractor and client have most to gain from ECI, as the experts answered unanimously for these two. Other stakeholders that were mentioned were the external stakeholders[14] and the designing firm, both with four mentions by the experts. When looking at the possible disadvantages, the client was mentioned again most (6 out of 11 experts), with the designing firm a close second (5 out of 11 experts). The same question was asked in Questionnaire 1,

[14] External stakeholders for construction projects are for example local inhabitants, regional commuters and subcontractors

with the mentioned stakeholders from the interviews as options. This yielded similar results and was therefore not further questioned in the second questionnaire for the sake of repetition.

6.3 Implementation of ECI

The previous results provided insight in the '*what*' and '*why*' for ECI in public construction projects. This section presents the results of the '*how*'. During the Delphi study several steps were made to identify the key players to take the initiative, the barriers and conditions for implementation and what factors determine the suitability of ECI for a construction project.

6.3.1 Barriers & Conditions for ECI

In the interviews the experts were asked if they could see possible barriers for ECI. This resulted in a mix of conditions and barriers, shown in table 10. This was followed by naming possible incentives to help overcome these barriers and conditions. The suggested incentives are shown in the corresponding column, also in table 10. Table 10 has some contradictions in the barriers and conditions when comparing them with the benefits, concerning the transaction costs and the risk distribution.

Table 10: Barriers, conditions and incentives for the implementation of ECI

Barriers & Conditions	Frequency of mentions	Incentives	Frequency of mentions
The procurement must be done differently	55%	Offer better compensation for tendering costs of the contractor	27%
The current culture makes effective use of ECI difficult	45%	Facilitate better communication between the client and the market	27%
The competition in the market needs to be guaranteed	27%	The use of Past Performance, like it is used in BVP	27%
There is fear at the client for the early contractual relation with a contractor	27%	An investment from a public client to experiment with ECI	18%
The division of roles needs to be changed between contractor and designing firm	27%	Incentives on behavior	9%
Dealing with the risks will change	27%	Proper implementation of an exit-clause	9%
The compensation fee for tender costs is often too low	18%		
There are too few projects to experiment or practice with ECI	18%		
Perseverance is required for all parties involved to learn to use ECI	18%		
Transaction costs are higher for the client	9%		
Tender costs will be higher for the contractor	9%		

From these results it became clear that the barriers and conditions had to be split, and the incentives had to be matched to the barriers they would help overcome. Questionnaire 1 tested the split of the barriers and conditions. Two barriers were found that surpassed the consensus threshold, and one that almost passed it. As it was easy to implement the third barrier in the Questionnaire 2, it was tested

again with the benefit of doubt. The same is done for the conditions and incentives. The barriers and their consensus percentages were:

- The client fears the early commitment to just one contractor (91% consensus).
- There is a lack of determination to experiment and implement ECI (55% consensus).
- It will be hard to secure the competition in the market properly (36% consensus).

The conditions found in the first questionnaire were the following four:

- The roles of the design firm, contractor and client must be redefined (64% consensus).
- The distribution of risks must be done different (64% consensus).
- Procurement will have to be specifically designed for ECI (55% consensus).
- More projects using ECI will have to be put to the market (36% consensus).

And the four incentives that may help to implement ECI are:

- An investment from the public sector to experiment with ECI (55% consensus).
- A proper exit-clause to terminate the contract must be available (46% consensus).
- The use of Past-Performance criteria for procuring projects with ECI (36% consensus).
- Apply incentives based on contractor behavior (36% consensus).

In the second questionnaire the link between the barriers and the incentives was investigated. The results are presented in figure 26, below. The figure shows that securing the competition for the market only has weak consensus (55%) for the Past-Performance criteria incentive, but the other criteria may also help. The incentive *"An investment from the public sector…"* could help to overcome the lack of determination to experiment and implement ECI. The fear of the client to commit early to just one contractor could be overcome by *"A proper exit clause…"*, *"The use of Past-Performance criteria…"* and *"Incentives based on contractor behavior"*.

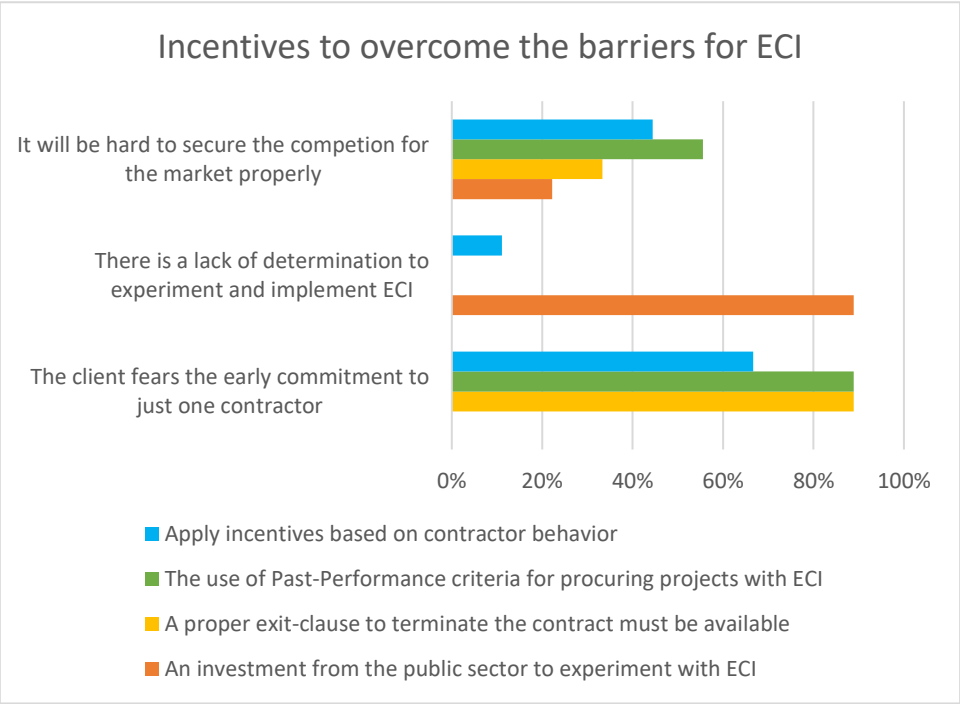


Figure 26: Incentives to overcome the barriers for ECI

The second questionnaire continued with the investigation of the conditions for ECI. The question aimed to identify the minimum conditions that will have to be fulfilled to be able to reach the potential of ECI. These minimum conditions were:

- Procurement will have to be specifically designed for ECI (78% consensus).
- The distribution of risks must be done differently (67% consensus).
- The roles of the design firm, contractor and client must be redefined (56% consensus).
- More projects using ECI will have to be put to the market (22% consensus).

These results are very similar to the results given earlier on the page above but give a signal that all the top 3 conditions must be met.

6.3.2 Other Practical Matters for Implementation

In between the interviews, Questionnaire 1 and 2 several other practicalities concerning the implementation of ECI were investigated. The first one was the matter of initiative. The response on which party should take the initiative for ECI was *the client* (64%) or *all involved parties* (36%). The explanation given by the experts was that the client is the only party with the real power to implement broader use or new methods for ECI. This was nuanced by some, as they stated that everyone involved in executing public construction projects should both prepare for, and practice with ECI.

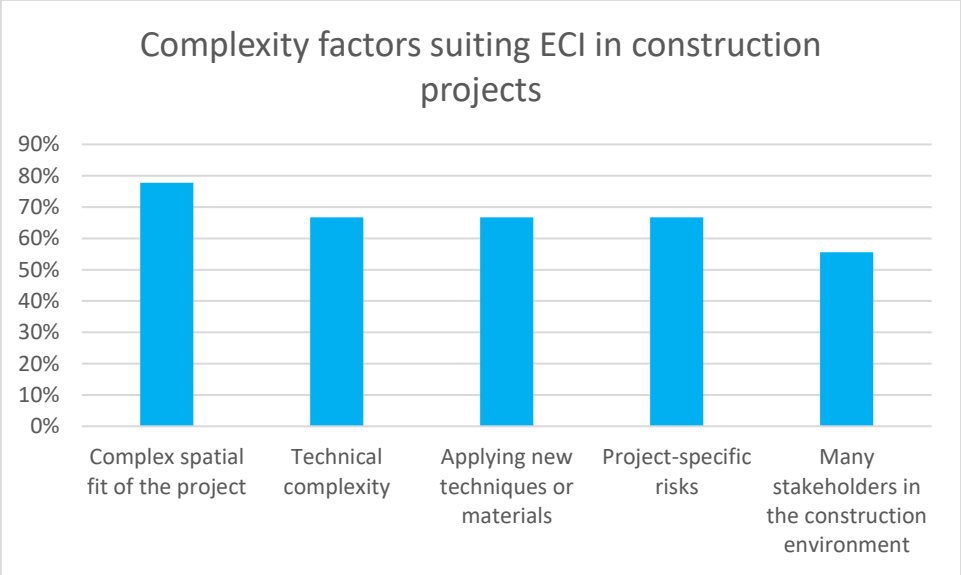


Figure 27: Complexity factors in construction projects fit for ECI

The factors that determine the suitability of ECI were further investigated in Questionnaire 2, following the degree of complexity that would determine the fit for ECI in construction projects. All facets concerning complexity tested surpassed the set threshold for consensus, as is shown in figure 27.

In addition to the complexity question for the fit of ECI, the level of thinking was also assessed in the second questionnaire. As this was an open question, there was no goal of consensus here. The experts responded with different aspects for the required level of thinking. Most mentioned that ECI requires people to be able to 'think outside the box'. Others answered that it required a more extensive cooperative attitude of all involved parties or expertise/experience on several different aspects of construction projects.

The final result of the Delphi study was the answer to the question *"Should ECI be used more and be further developed in the Netherlands?"* yielded 73% consensus on "Yes" on the former question. The mentioned reasons why varied between the earlier discussed benefits to ECI, to ECI being the logical next step to improve efficiency in public construction projects and; the value of ECI not only to those directly involved but to the Dutch society as a whole.

6.4 Confirmation of the Results

The confirmation of the results has been done by Prof. dr. ir. M.C.J.M. Hertogh. Most of the findings of the Delphi panel have been confirmed by Mr. Hertogh. The results that were not recognized in the confirmation session are summarized and shortly discussed below, whilst the full result of the confirmation session can be found in Appendix E.

The first result that was partially unconfirmed was the *cost reduction* benefit. According to the confirmation session, cost reduction can be achieved through ECI, but only if this is the goal. It was stated that the benefit is broader; ECI gives higher value for money. This could either be the same quality for a smaller price, or a higher quality for the same or slightly higher price. The results have shown that the cost reduction benefit only appears in specific cases. Higher project quality is more balanced in appearance between *only in specific cases* and *always.* This could be interpreted to be in line with the reasoning of discussed in the confirmation session.

Several of the unconfirmed results have the same reasoning for not being confirmed; This goes for the disadvantage *'an early contractual relation between client and contractor limits the flexibility of the client'*; the statement '*the disadvantages of ECI are primarily for the client*' and; the barrier *'it will be hard to secure competition in the market with ECI'*. For these results goes that proper design, preparation and communication will nullify these results from the Delphi study.

The list above shows the 7 out of 32 findings that were tested and not recognized by Mr. Hertogh. The other roughly 80% of the findings were recognized and therefore confirmed.

7. Conclusion

This chapter is dedicated to interpreting the results and answer the research questions of this thesis. As the answers to the sub-questions build up to the answer of the Research Question, this chapter follows that order. The Research Question is:

"What is the potential of ECI in the Dutch public construction industry?"

With the corresponding sub-questions:

1. What is Early Contractor Involvement (ECI)?
2. What is the effect of ECI on construction projects?
3. What are the requirements for the implementation of ECI?
4. What are the implications of the use of ECI for the Dutch construction industry?

7.1 What is Early Contractor Involvement (ECI)?

Literally, ECI is involving the contractor "early". In the Delphi study came forward that "early" refers to "earlier than the moment of involvement in the current practice". From literature became clear that there are several definitions used for ECI. Some definitions refer to procedures in construction (like in the UK & Australia) and others refer to the literal principle of involving a contractor "early". The early involvement of the contractor in the Netherlands was specified in literature as either Interweaving, Design Team or PDC. For PDC was too little literature available to specify ECI within the procedure. For Design Teams no specific starting point of involvement of the contractor is specified. However, Design Teams are said to be able to benefit from ECI when done properly. As the literature study shows, interweaving has several starting points defined for involvement of the contractor.

During the scoping round, it became clear that ECI is seen in very different ways and that defining ECI unambiguously would be a challenge. The starting point was therefore set very broadly; "*involving a contractor in the planning phase*". During the Delphi study it became clear that no unambiguous definition for ECI would be found. The ideas of the experts in the panel on what ECI is and how to use it differed too much for a thesis-size Delphi study. However, definition space for ECI has been demarcated further than it was before. ECI is either consulting a contractor by ways of market consultation or entering a contract with one contractor during the initiation phase of a construction project.

When following these definitions, both forms of ECI are already being used in the Netherlands. The results in tables 7 & 8 show that ECI can be used in all 3 existing forms of collaboration discussed in the literature study (PDC, Design Teams & Interweaving). Even the legislation in the Netherlands is said to be fit for ECI in the case of the UAV-GC, but a new contract type may be even better. This is in line with the finding that ECI is already being used, but not to its potential.

Concluding, the answer to this sub-question is; ECI is involving the contractor earlier than is currently the standard in public construction projects, which can be done in two ways. Firstly, by consulting a contractor before procuring the project, or secondly, by entering a contract with a contractor in the initiation phase.

7.2 What is the effect of ECI on construction projects?

The effect of ECI consists of the benefits and inherent disadvantages of the use of ECI. The literature on ECI showed a very positive balance in favor of the benefits of ECI, with very few disadvantages being put forward. During the Delphi study it became clear that almost all these benefits are possible with ECI. The study also revealed more possible disadvantages, but the consensus here was weaker than with the benefits. An overview of the benefits and disadvantages from literature and the Delphi study

results can be found in table 11, below. The results from the literature study and the Delphi study are displayed to show the similarities between the results.

Table 11: Summary of the results of the benefits and disadvantages from literature and the Delphi study

Benefits	Literature	Delphi Study	Disadvantages	Literature	Delphi Study
Improved risk distribution, assessment and management	x	x	Inexperience with ECI, market is not ready to exploit ECI	x	x
Higher certainty in costs	x	x	Insufficient incentives for the implementation of ECI	x	
Higher certainty in planning	x	x	Early contractual relation limits the flexibility for the client		x
More freedom for creativity and innovation for the contractor	x	x	ECI requires a certain level of thinking		x
A reduction in costs	x	x			
Higher project quality	x	x			
Quicker project delivery	x				
Better executability of the project		x			

Table 11 shows that the disadvantages from ECI are less agreed upon than the benefits. The Delphi panel revealed two disadvantages surpassing the consensus threshold, which cannot be linked to the disadvantages found in literature. The reason for this could be that even though the experts have worked with the forms of collaboration and contract types that incorporate some aspects of ECI, ECI still is very new in the Netherlands in the form discussed in the section above.

The results show that benefits of ECI are likely to occur more often than the disadvantages. The top 4 benefits from table 11 are said to appear often, whilst the bottom 4 are said to appear mainly in specific cases. The disadvantages are all said to appear only in specific cases, with very few outliers. When comparing the benefits to current practice, the results show that ECI provides most improvement when compared to D&C projects. This implies that the best option for implementing ECI would be in D&C contracts.

The other forms of collaboration have less to gain from ECI than D&C contracts. When relating this to the results of the use of ECI in the Netherlands, it seems logical that PDC and Design Team provide less benefits. Both forms of collaboration already use ECI to a degree, which means that there is less to gain than forms that do not use ECI yet. However, the results show that even though ECI is being used already, a lot more potential remains unexploited.

The benefits of ECI are primarily for the client and the contractor. This is logical as these parties have the highest stakes in any construction projects. When reviewing the disadvantages, it also fits that the client has most to lose. Especially the reduction in the flexibility for the client is a disadvantage a public client will not take lightly.

Concluding this section, ECI can contribute a lot of benefits to construction projects with few disadvantages. The benefits depend on proper timing and use of ECI. Both the benefits and disadvantages do not come naturally but depend on specific application and cases.

7.3 What are the requirements for implementation of ECI?

The implementation of ECI is investigated in terms of barriers, conditions and incentives. The conditions found in the research can be seen as the base requirements for the implementation of ECI. The barriers concern specific issues, which could be overcome by using the incentives described.

The conditions found in the research show that ECI is not easily embedded in the current practice of public construction works. Both the procurement and the role distribution of the involved parties needs to be changed to fit ECI. As the contractor will be taken on board earlier, the risk distribution also needs to change. In theory, the risks should be allocated to the party best capable of carrying that risk. Because ECI based on a contract reduces the flexibility of the client in the early phases, new risks can emerge, which have to be managed in such a way that both contractor and client can be confident that ECI is of actual benefit.

The barriers found in the Delphi study relate primarily to the client. The early commitment to one contractor yields the disadvantage of the reduced flexibility for the client. As this is regarded as potentially problematic for the client, the client is rightfully reluctant to use ECI. This results in very few to zero experiments with ECI[15], which could be seen as a lack of determination to make ECI work.

The incentives found in the Delphi study can overcome the barriers for the implementation of ECI for the client. A mix of incentives on contractor behavior, applying past-performance criteria during procurement of ECI projects and a proper exit-clause can take away the reluctancy of the client to use ECI. These incentives will have to be tailor-made for ECI to be efficient and the only way to do so is to experiment with ECI. Reaching the potential of ECI requires experimenting with ECI and because of the reluctance of the client, outside investment from public bodies or commitment from public clients to make ECI work can help.

The focus on the client to take initiative is clear from the results. The public clients like Rijkswaterstaat have the power to bring projects to the market to experiment with ECI. But the experts from the client perspective and some from the design firm perspective reveal a lack of confidence that ECI will work. They name inexperience of the contractor in an advising role and the required level of thinking and attitude as factors that make or break early experiences with ECI.

The eligibility of ECI for construction projects seems to fit all construction projects. The results show that any form of complexity in a project makes the suitability for ECI better, but the results also show

[15] The only project that can currently be considered an experiment with ECI is the PDC project Hoevelaken.

that ECI yields benefits for projects of low complexity. With the current practice in mind, the suitability of ECI lies more with the people using it and the forms of collaboration it replaces or improves.

As is discussed in the first section of this chapter, existing legislation can already accommodate ECI. The UAV-GC could be used for projects with ECI, even though it may require some minor changes. However, a new contract type, tailor-made for ECI would be even better.

In conclusion, the requirements for implementation of ECI consist of several factors. Firstly, the conditions must be met to create a basis to facilitate ECI. Secondly, the initiative for practice with ECI lies primarily with the client. Experiments with ECI are few, so the contractors (and any other parties involved) have a high responsibility for the future of ECI. Good results will lower the reluctance for the client and allow momentum to be gained with ECI. To kick start this process, investment and determination are needed from the public clients. In addition, the preparation for application of ECI with regard to procurement, risk distribution and clear commitment from all people involved should enable ECI to be implemented in the Netherlands. When the experiments yield bad results, further experimentation is unlikely to continue.

7.4 What are the implications of the use of ECI in the Dutch construction industry?

The implications of ECI are discussed in two ways. The first is by relating ECI to the public construction project system created in chapter 5 *Scoping Round*, which is used as a theoretical framework in this research. The second way is by discussing the implications for the use of ECI in the Dutch construction industry.

7.4.1 Implications on the Theoretical Framework

The benefits and disadvantages of ECI are fitted on the system that is used as the theoretical framework. This resulted in figure 28 on the next page. Table 12, below here, is the legend to figure 28 and shows the benefits and disadvantages corresponding to the colored arrows in the figure. The blue arrow on the top of the figure indicates the moment of contractor involvement. The moment shown in the figure indicates the most likely moment of involving the contractor, according to the interpretation of the results by the researcher.

Table 12: Support list for benefits & disadvantages in figure 28

BENEFITS		DISADVANTAGES	
1	Improved risk distribution, assessment and management	1	Inexperience with ECI, market is not ready to exploit ECI
2	Higher certainty in costs	2	Insufficient incentives for the implementation of ECI
3	Higher certainty in planning	3	Early contractual relation limits the flexibility for the client
4	More freedom for creativity and innovation for the contractor	4	ECI requires a certain level of thinking
5	A reduction in costs		
6	Higher project quality		
7	Quicker project delivery		
8	Better executability of the project		

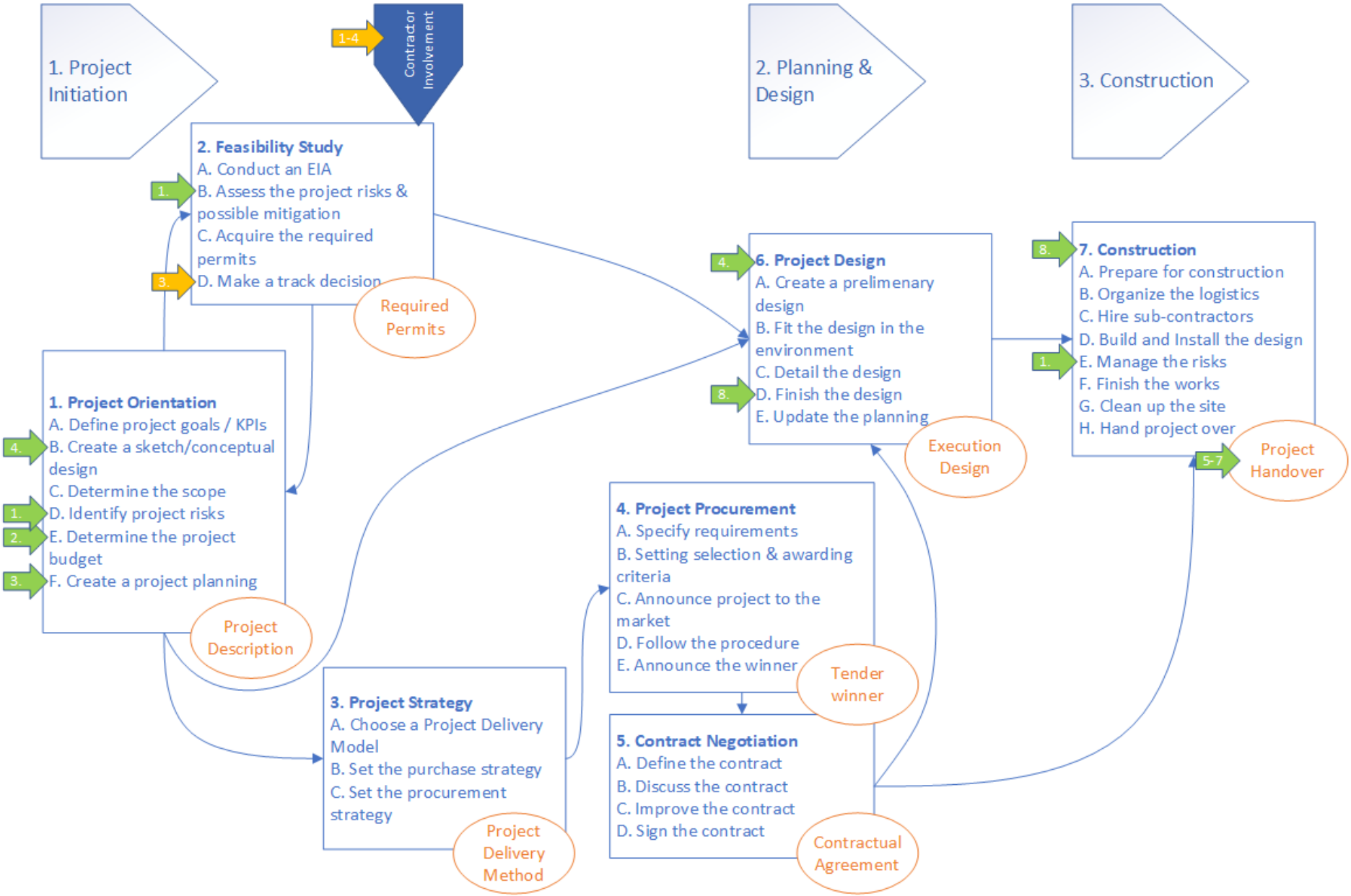


Figure 28: ECI applied to the theoretical framework constructed in the Scoping Round chapter

Figure 28 reveals the factors in the project where the expertise of the contractor benefits the project. By involving the contractor early, *Project Procurement* should shift leftward in the figure together with the *Contractor Negotiation*. This increases the work that has to be done in preparation of the project, which decreases the work for the client in the later phases.

From figure 28 it becomes clear that the benefits of ECI are easy to make tangible. The disadvantages however, are not. The disadvantages from literature and the Delphi study are more concerned with the process of collaboration than with the actual execution of the project. The only disadvantage that can be applied to the framework is the reduced flexibility of the client, but even this can be considered a stretch. When the barriers and conditions are added to the consideration, the figure shows that ECI is likely to be new and unfamiliar for most. The results show that the identified barriers and conditions are mainly concerned with further implementation of ECI. When ECI is implemented more often, the barriers and conditions can be assumed to be either fulfilled or no longer relevant. The same goes for the disadvantages; when ECI is used more often, inexperience with ECI (disadvantage 1 in figure 28 and table 12) turns into experience. This experience will help to reap the benefits of ECI and therefore creating momentum for the concept, which is likely to increase application of ECI even more. At this point, incentives might not be necessary anymore as the concept will most likely have proven itself. The reduced flexibility of the client may still be a problem for some projects, but careful preparation and application of ECI should be able to overcome this. And if the flexibility is considered a very important project aspect, this could either be set as a criterium during procurement, or maybe a different form could be used for the project.

7.4.2 Implications for the Dutch Construction Industry

As the section above discusses the implications of ECI on project level, this section goes in depth on the implications of ECI on the construction industry for public construction projects. This is done by first discussing the current state of the construction industry and then the changes that ECI may bring in the future.

The results have shown that the construction industry for public projects is not ready for ECI yet. But the barriers and conditions that are identified could be the start for change. The traditional distribution of roles is reinforced by the professional capacities and expectations the parties have of themselves and their jobs. Currently, the client initiates a project and designs it with the help of a designing/engineering firm. When the design is finished, the project is procured, and the contract is awarded to a contractor. The client then either monitors the project or appoints a third party to do so. The second option is that the client makes a preliminary design (with or without the help of a designing firm) or a functional specification of what the project should become. The contractor can then be contracted to create or finish the design based on the work done before. As most contractors do not have the designing and engineering capacity required for most projects, they hire a designing firm to help work out the design.

From the responses in the interviews and the description above follows that the client has little or no technical proficiency to design a project themselves. The contractor has some capacity to do design and engineering work, but the core business is still to actually construct the project. The engineering firm has the capacity to help both, but has little (or at least less) practical understanding of the building process.

When ECI becomes more common, the results imply that contractors will have to do even more design work than in a D&C project. They will also have to do something new; advice the client. This advising role is not developed at the contractor, as is concluded based on the results of the study. The contractors have to generate the capacity and expertise to fill an advising role. As more of the designing

and advising work will be picked up by the contractor, it is likely to assume that less of this work will fall to the designing firms. Therefore, a shift from designing and engineering capacity may occur from designing firms to contractors.

When the contractors gain more and more expertise and a larger share of the work in public construction projects, the gap between the expertise of the client and contractor is likely to grow. As this gap grows larger, effective communication regarding technical aspects of the project is likely to become more difficult. This could result in increased opportunities for strategic/opportunistic behavior of the contractor. To prevent the negative results of this behavior, public clients could take more engineers on board to fulfill their demands and wishes for the project. By collaborating on the same level between client and contractor early on, the resulting contract can be drawn up and defined better than the way it happens now. Another possible option to solve this problem is to give the designing firm a more representative role. If the client prefers this option to taking engineers on board, then the designing firms will have a role change. The role of supervisor/consultant is likely to become more prominent for the design firm. In this case, this does not necessarily imply a decrease in the share of work. As these implications are not mutually exclusive, it is deemed likely that a combination of both will occur.

The results show that the current procurement is not fit to procure projects with ECI. As the moment of procurement moves to an earlier stage in the project than is current practice, less of the project is designed and specified. Therefore, it is harder or even impossible to take price into account to select a contractor. The use of Past Performance criteria (and possibly other functional or behavioral criteria) can help tailor procurement criteria and procedures to fit ECI.

In summary, ECI has the following implications for the construction industry:

- Either designing and engineering capacity will shift from the designing firms to the contractors and possibly to public clients as well, or, the design firm will take on a more representative role for the client. A combination of both is most likely to occur.
- Contractors are likely to develop their expertise in an advising role.
- Procurement will be less aimed at price as primary criterium but focus more on behavioral or functional criteria.

7.5 What is the potential of ECI in the Dutch public construction industry?

The answer to the Research Question *"What is the potential of ECI in the Dutch public construction industry"* consists of several aspects. First and foremost, ECI has the potential to bring eight benefits to public construction projects:

1. Improved risk distribution, assessment and management
2. Higher certainty in costs
3. Higher certainty in planning
4. More freedom for creativity and innovation for the contractor
5. A reduction in costs
6. Higher project quality
7. Quicker project delivery
8. Better executability of the project

To reap these benefits, ECI has to be implemented in the Dutch public construction industry. The results of the Delphi study imply that four conditions have to be met, and three barriers must be overcome to implement ECI. Four incentives have been identified that can help to overcome these three barriers. In addition to overcoming these barriers and fulfilling the conditions for implementation

and increased use of ECI, it is important to note that ECI requires people with a certain level of thinking, from all parties. As ECI contains several ‘new’ aspects, the success of ECI in the early stages lies with the people collaborating to make both the project and ECI a success. When ECI becomes common in the Netherlands, the benefits will appear more often and the role division of the client, contractor and designing firm will change. It is expected that designing and engineering capacity will shift primarily to the contractor and possibly to the client as well. Contractors familiar with ECI will develop their advising role and thereby bring their expertise earlier and more effective to the table. With the help of ECI, public construction projects can be completed with higher certainty, higher quality and with a better process than is the current practice. This can improve public construction projects and possibly even help improve the poor image of public construction projects today.

8. Discussion

The Delphi study on ECI provided several points worth discussing in this chapter. First, the implications of this research and the fit of the results in relation to the defined knowledge gaps are discussed. This is followed by the discussion on the confirmation session and, more specifically, on the unconfirmed results. Third, the Delphi methodology is discussed. Fourth, the recommendations for further research are given and fifth, a personal reflection of the researcher on the conducted research is provided.

8.1 Implications of this Research

As already indicated in the introduction, there is quite some research on ECI available. The problem is however that the terminology "early contractor involvement" is used loosely for several practices and procedures, which makes comparison between projects with ECI impossible. The knowledge gaps identified in the chapter *Research Approach* were twofold. The **theoretical gap** is an unambiguous definition what ECI really is, what it should be and what the benefits for ECI then are for theory. The identified knowledge **gap in practice** is the way the in-theory-defined ECI principle can be implemented in public construction projects.

This study aimed to set one, unambiguous definition for ECI, but this seemed impossible within the boundaries of the research. The results of the study did help in narrowing the solution space for the definition a lot compared to the chaos that existed before. The two different types of ECI (the consulting type and the contracting type) provide a fair basis to compare projects with ECI. The study also confirmed a lot of benefits found in literature and added some more. As a result, the knowledge gap that existed has partially been filled by this research.

The knowledge gap in practice consisted of the *how* to gain the theoretical benefits of ECI. The Delphi panel revealed several barriers and conditions to help implement ECI more in the Netherlands. As the benefits will be easier to reap when more experience is gained with ECI, starting momentum is probably all that is required. The problem here is that the early experiences with ECI have to be positive. Both in the Delphi study and the confirmation session was reiterated that the people experimenting with ECI can make or break these early experiences. But as mentioned earlier, there is very little experience with ECI in the Netherlands. Because ECI still is a very new concept, it requires extraordinary thinking, preparation and leniency in the early experiments with ECI. And when the projects are finished, the lessons learned from these projects have to be transferred and implemented for all parties involved. ECI requires determination and perseverance from the people practicing ECI to prove the value it can have for the public construction industry. When this succeeds, ECI will gain momentum and will be embedded in the construction sector and change the market accordingly.

8.2 Discussion on the Results

This section first discusses the results on the definition of ECI. This is followed by some less-certain implications of ECI on the construction industry. It continues with a reflection on the perspectives in the public construction industry as discussed in the *Scoping Round* chapter. The section concludes with some remarks regarding the confirmation session.

The results of the Delphi study showed that the panel suggested two definitions for ECI; a *consulting* definition and a *contracting* definition. As the consulting definition is restricted to a Market Consultation, this has the unambiguous definition 'Market Consultation' already. Therefore, it may be better to drop the consulting definition altogether and adopt the contracting definition of ECI. Doing so may help to prevent confusion and satisfy the theoretical knowledge gap of this research better than the two separate definitions did.

The high complexity in projects that would be preferred to use ECI was not confirmed. In the opinion given in the confirmation session, it was deemed obvious that more intensive collaboration (like ECI) is beneficial to complex projects. However, fact is that 'simple' projects can benefit as well. As contractors have built many 'simple' projects already, they have almost standardized the construction of these projects. In addition to the beneficial economy of scale that is in effect by standardizing projects, they can provide exact examples of what the finished project will look like. This enables the client to shop for their desired project from a sort of catalogue of standardized projects. Doing so reduces the effort the client has to put in, as there is minimal design work to be done. More responsibility can shift to contractor, making standard projects a lot more efficient.

When assuming that the construction industry adapts ECI and the market has changed accordingly, some additional implications may occur. For example, when contractors have all the expertise from advising, designing and constructing works, they could become big enough to fully develop projects. Smaller designing and consulting companies would become part of the larger contractor, decreasing variety in the options for contractors in the market. This could be interpreted as a problem. But if it improves the efficiency of public construction works, it may very well be worth it.

Another aspect that is not discussed earlier is the workload on the client. ECI is reflected on the Design Team form of collaboration in the literature study. As the client is part of the coordination agreement there, the client is likely to have a significant workload during the project. When reflecting this on the two likely options for ECI as discussed in the *Scoping Round* chapter, the workload for the client can change a lot (and not only in regard to the Design Team).

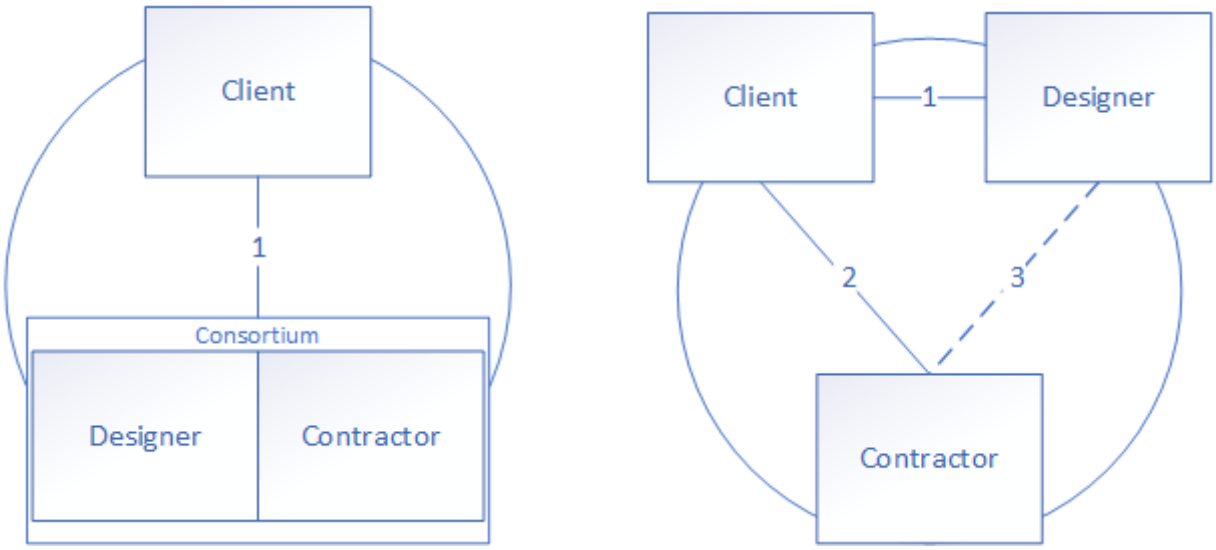


Figure 29: Possibilities for the relations with ECI

Figure 29 shows the two options that were discussed earlier. The left option resembles the current relation PDC projects are likely to have. This form can, if applied early enough, represent ECI as well. The right option suggests that the designer takes on the role of the traditional consultant and acts as representation of the client. In this scenario, the client only takes on initiation and procurement of the project. When this is done, the client can step back and let a more technically qualified company handle the detailing of the design and the construction. Both options are able to accommodate ECI and can perhaps be applied to different projects, depending on the strategy chosen by the client.

The confirmation of the results gave confidence in both the way the methodology was applied and the concept of ECI. During the session, a lot of points that became discussion points in the interviews and the commentary boxes of the questionnaires were nuanced and put into perspective. The most evident

example of this was the general attitude; Mr. Hertogh was very positive about the concept and confident on possible implementation after proper preparation, whilst the panel in general was positive on the concept but a lot less confident on the realism of use of ECI. This difference is somewhat difficult to explain, as the experts in the panel and the expert in the confirmation session have experience in common. A possible explanation could be the experience of Mr. Hertogh as IPM professor and as top-advisor for Rijkswaterstaat. In conclusion, the confirmation session gave confidence in the research results and the application of the methodology for an inexperienced Delphi researcher as myself.

8.3 Discussion on the Methodology

The Delphi methodology is not often used in thesis research. At the start of this research, no apparent reason was found for this. However, during the research several reasons surfaced for this phenomenon. The Delphi methodology has been under a lot of scrutiny in the academic community, as is already discussed in the *Methodology* chapter. But the use of the Delphi method is to fill the gap where quantitative research is unable to go, and therefore it was used for exactly that goal in this thesis. For this study on ECI, it was impossible to compare projects, as there simply was no distinctive definition for ECI available. The next issue is the fact that the duration of a proper Delphi study lasts until either consensus is reached, or subsequent rounds do not change the results any more. Fitting these options in a research period of six months is impossible. To fit the method to the research for this study, it was determined to set the number of rounds to a maximum of three. Doing so decreased the potential of the study before the study begun. As the time was limited, some questions may have been imperfectly formulated and some questions may not have been asked at all. In hindsight it is possible that, for example, more depth could have been achieved on the implementation questions. The final issue with the Delphi methodology is the expert selection and resulting panel size. Because time is a limiting factor in thesis research, the selection of the experts cannot be too rigorous. Concessions to the quality of the panel have to be made for the sake of availability of experts in the period of the research. In addition, the size of the panel is also limited. This limitation, together with the maximum available rounds due to the available time reduces the potency of the method for thesis research.

However, even though the method may be unfit for thesis research, most results have been confirmed during the confirmation session and the knowledge gaps in theory and practice have been filled at least partially. Therefore, the research is deemed successful by the researcher.

When reviewing the process of the research, it becomes clear that mitigation measures taken to successfully conduct the Delphi study worked. Table 13 shows the attrition rate during the research, which averaged 9% over 3 rounds. As attrition is always a point of concern in research consisting of multiple rounds of surveys, 9% is considered a decent result. During the process of the study, the communication between the researcher and the experts could have been better. Especially for some of the definitions used in the interviews and questionnaires. Although the difference between a contract type and a form of collaboration is clear in academic research, the comments from the experts on the results showed that this was not necessarily the case for the experts. This implies that some of the results may have suffered a ‘loss in translation’ in the interpretation of the questions. The solution to this problem would have been simple; as the definitions were set during the scoping round of the Delphi study, a list of the definitions should have been presented to the expert panel when the interviews and questionnaires were conducted.

Table 13: Attrition monitor for the Delphi study

Rounds	Interviews	Questionnaire 1	Questionnaire 2
Respondents at start	12	11	11
Attrition Rate per round	8%	0%	18%
Respondents at end	11	11	9
Average attrition rate per round			*9%*

The composition of the panel has been discussed earlier in this thesis. The attrition of the study comprised of three experts; two experts from the contractor perspective and one of the design firm perspective. This may have skewed the results in the last questionnaire, but not necessarily. As stated before, the conceptual level of thinking criterium in the selection of the experts and the roles the experts from the design firm perspective have, helped to yield representative results. As most of the results have been confirmed, the results of this study should be generalizable to public construction projects in the Netherlands. Further research and experimentation with ECI will determine the accuracy and usability of the results.

On a final note, it is interesting to see how the responses from the panel evolves. The Delphi method is based on the principle that experts, when confronted with the opinions of others, are willing to change their view. During the study this was observed as well. This principle, however interesting, raises the question on how great the expertise of the experts really is – if someone knows the answer for certain, he or she will not change an earlier given answer. But this is exactly where the catch is; if something can be known for certain, it should not be tested with a Delphi panel. In addition to this, every result from the Delphi study is as valuable as the expertise in the panel and the meticulousness of the researcher in the application of the method.

8.4 Recommendations for further Research

Further research on ECI is recommended. The benefits found in both literature and the results of the Delphi study indicate that ECI is a valuable concept. The reluctance of the client to experiment with ECI is understandable, but proof of concept will only be gained when the concept is tested. These recommendations are made under the assumption that the exploratory research in this thesis is sufficient. If this would not be the case, another Delphi study might be able to do so. The scale of this Delphi study will have to larger than the study that is conducted here. This implies a larger expert panel and rounds either until consensus is reached or the results change no longer. In addition, the concept of 'expert weight' as already shortly explained in the *Methodology* chapter could help to get better results.

Before testing the concept, it is important to prepare properly for the use of ECI. This requires several things. Firstly, research has to be done to design a procurement method with selection criteria for ECI projects. This can be done by either researching different procurement methods used in current practice, or by testing new criteria for test-projects with (elements of) ECI. Secondly, the right people must be involved in the early stages to make ECI a success. When ECI is proven to work, forward momentum will carry the development and use of ECI further. Thirdly, the early phases of experimentation of ECI have to be monitored closely and require learning from the made mistakes and possible improvements. And fourthly, experiments and tests must be made available by public clients. Without projects to experiment and learn from, ECI will not be implemented and improved further than it is today.

In summary, the recommendations for further research are (1) a study to further investigate on the '*how'* ECI should be implemented, on a more detailed level. The result of this study should provide a guide on how to use and test ECI. When this study is completed, (2) case studies have to be done on experimental projects with ECI. Only when the cases are carefully studied, and lessons learned have been found and implemented, the use of ECI can be improved for next experiments.

8.5 Personal Reflection

This research has been a challenge in two ways; firstly, because the method was unfamiliar and secondly because ECI proved to be a complex subject. When reviewing the methodology, I do believe the method fits the research. The results the Delphi method yielded are usable for further research, without requiring the daunting task of unambiguously defining ECI. Either definition (consulting or contracting) could yield its own further research and consecutive benefits. Using the Delphi method was both fun and frustrating; using interviews in the first round was interesting and helped shape the further rounds. During this process it evolved the subject and understanding of the concept. The results seem great, but the process to get there is often not evaluated. I believe that by asking the experts who would encounter ECI in their work, a realistic view of the conditions and barriers has been given. On the other hand, the confirmation session made me reconsider the results considering the barriers and conditions. Proper design of the procedures and agreements can shape ECI better and therefore remove a lot of the problems.

Early Contractor Involvement is something that surfaced some 10 years ago but is interpreted differently everywhere it is used nowadays. This is logical, as the legislation for public construction is different per country. But this does bring a problem; there is no ready-to-use definition or procedure available. This requires careful deliberation on how to approach ECI for each country differently and feels like reinventing the wheel, time and time again. The story of ECI in Australia felt especially typical. The market there clearly stated that ECI would benefit the construction industry and that they were eager to start using it. But public entities did not want to take the risk and kept using traditional methods for years to come. When relaying this to the Dutch construction industry, the construction industry has a similar traditional image. Implementation of something rigorous like ECI is therefore unlikely to go easy. In addition to this, a final difficulty regarding ECI came from an unexpected side for me. As an academic, definitions for things like "project delivery models", "contract types" and "forms of collaboration" are clear. In practice, people use these terms more or less interchangeably. As I realized during Questionnaire 2 that the experts did not all use these definitions in the same way as I do, the responses and following results of the research may be interpreted differently than I intended them.

Concluding this thesis, I think this research has been valuable and a proper stepping stone for further research on ECI. I hope other researchers on ECI can put the results in the proper perspective and help to implement ECI in public construction projects, because I believe ECI is the logical next step in improving public construction works.

Bibliography

Altamirano, M. A., & de Jong, W. M. (2009). Opportunistic Behavior in Road Maintenance Markets. *Transportation Research Record: Journal of the Transportation Research Board*, *2108*, 13–22. https://doi.org/10.3141/2108-02

Arnold, R. D., & Wade, J. P. (2015). A definition of systems thinking: A systems approach. In *Procedia Computer Science* (Vol. 44, pp. 669–678). Elsevier. https://doi.org/10.1016/j.procs.2015.03.050

Boes, H., & Dorée, A. (2013). Public Procurement At Local Level in the Netherlands: Towards a Better Client- Contractor Cooperation in a Competitive Environment. In *Proceedings of the 29th Annual ARCOM Conference* (pp. 717–727). Retrieved from http://www.arcom.ac.uk/-docs/proceedings/ar2013-0717-0727_Boes_Doree.pdf

Boyd, D. (Professor), & Chinyio, E. (Ezekiel). (2006). *Understanding the construction client*. Blackwell. Retrieved from https://books.google.nl/books?hl=nl&lr=&id=3jsE1WXuw-MC&oi=fnd&pg=PR3&dq=boyd+chinyio+&ots=8IiFjtlDwV&sig=ZngI7JiALTgxTxSLFyAyMZ_bThU#v=onepage&q=boyd chinyio&f=false

Bundgaard, K., Klazinga, D., & Visser, M. (2011). Traditional Procurement Methods Are Broken : Can Early Contractor Involvement Be the Cure? *Terra et Aqua*, *11*(1), 8. Retrieved from https://www.iadc-dredging.com/ul/cms/terraetaqua/document/2/9/9/299/299/1/article-traditional-procurement-methods-are-broken-can-early-contractor-involvement-be-the-cure-terra-et-aqua-124-4.pdf

Chao-Duivis, M. A. B. (2012). *Het bouwteam model : een studie naar de juridische vormgeving en het functioneren in de praktijk*. *Bouwrecht monografieën, 1574-1915 ; nr. 34; Bouwrecht monografieën ; 1574-1915 nr. 34.* Retrieved from https://www.ibr.nl/site/assets/files/1086/bouwteam_inhoudsopgave.pdf

Chao-Duivis, M. A. B., Koning, A. Z. R., & Ubink, A. M. (2013). *A Practical Guide to Dutch Building Contracts* (3rd ed.). Den Haag: Instituut voor Bouwrecht.

Chen, G. K. C. (1975). What is the Systems Approach? *Interfaces*, *6*(1), 32–37. https://doi.org/10.1287/inte.6.1.32

Cobouw. (2010). FIDIC voorziet in behoefte met uitbrengen serie contractvormen - Cobouw.nl. Retrieved February 23, 2018, from https://www.cobouw.nl/bouwbreed/nieuws/2010/05/fidic-voorziet-in-behoefte-met-uitbrengen-serie-contractvormen-101142658

Cox, D. O., Molenaar, K. R., Ernzen, J. J., Henk, G., Matthews, T. C., SMITH, N., … Yakowenko, G. (2002). Contract Administration: Technology and Practice in Europe, *7*(2). Retrieved from https://international.fhwa.dot.gov/contractadmin/contractadmin.pdf

Dalkey, N., & Helmer, O. (1963). An Experimental Application of the DELPHI Method to the Use of Experts. *Management Science*, *9*(3), 458–467. https://doi.org/10.1287/mnsc.9.3.458

Davis, P., Love, P., & Baccarini, D. (2008). Building Procurement Methods. Retrieved from http://www.construction-innovation.info/images/pdfs/Research_library/ResearchLibraryC/2006-034-C/reports/Report_-_Building_Procurement_Methods.pdf

de Koning, J. N. (2018). Het nieuwe bouwteam - Cobouw.nl. Retrieved February 19, 2018, from

https://www.cobouw.nl/bouwbreed/blog/2018/02/het-nieuwe-bouwteam-101257750

de Ridder, H. A. J. (2009). Design and Construct in Civil Engineering, (May), 54–55.

Donohoe, H. M., & Needham, R. D. (2009). Moving best practice forward: Delphi characteristics, advantages, potential problems, and solutions. *International Journal of Tourism Research*, *11*(5), 415–437. https://doi.org/10.1002/jtr.709

Eriksson, P. E. (2010). Partnering : what is it, when should it be used, and how sould it be implemented? *Construction Management and Economics*, *28*(Level I), 905–917. https://doi.org/10.3113/FAI.2010.1033

Eriksson, P. E., & Westerberg, M. (2011). Effects of cooperative procurement procedures on construction project performance: A conceptual framework. *International Journal of Project Management*, *29*(2), 197–208. https://doi.org/10.1016/j.ijproman.2010.01.003

European Union. (2014). Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC. *Official Journal of the European Union*, *2014*(28.3.2014), 65–242. https://doi.org/2004R0726 - v.7 of 05.06.2013

Fink, A., Kosecoff, J., Chassin, M. R., & Brook, R. H. (1991). Consensus Methods. Retrieved from https://www.rand.org/pubs/notes/N3367.html

Flyvbjerg, B., Holm, M. S., & Buhl, S. (2002). Underestimating costs in public works projects: Error or lie? *Journal of the American Planning Association*, *68*(3), 279–295. https://doi.org/10.1080/01944360208976273

Hermans, M. H. (2017). CME5000 - Project Delivery Models. Delft: TU Delft.

Kadefors, A. (2017). Private Consultation. Stockholm.

Kamminga, P. (2012). Aanbesteding Een Goede Basis Voor Samenwerking? Een Analyse Van Aanbestedingsregelgeving Vanuit Samenwerkingsperspectief (Analysis of Procurement Law from a Cooperation Perspective). *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2300968

Klijn, E. H. (2009). Public-private partnerships in the netherlands: Policy, projects and lessons. *Economic Affairs*, *29*(1), 26–32. https://doi.org/10.1111/j.1468-0270.2009.01863.x

Knutsson, H., & Thomasson, A. (2014). Innovation in the Public Procurement Process: A study of the creation of innovation-friendly public procurement. *Public Management Review*, *16*(2), 242–255. https://doi.org/10.1080/14719037.2013.806574

Koenen, I. (2017). Bouwteam bezig aan opmars: “Een teken van groeiend vertrouwen” - Cobouw.nl. Retrieved March 5, 2018, from https://www.cobouw.nl/bouwbreed/nieuws/2017/11/bouwteam-bezig-aan-opmars-een-teken-van-groeiend-vertrouwen-101255490

Koenen, I., & van de Pol, G. (2015). UAV-gc moet volledig op de schop - Cobouw.nl. Retrieved January 16, 2018, from https://www.cobouw.nl/bouwbreed/nieuws/2015/10/uav-gc-moet-volledig-op-de-schop-101127823

Lahdenperä, P. (2012). Making sense of the multi-party contractual arrangements of project partnering, project alliancing and integrated project delivery. *Construction Management and*

Economics, *30*(1), 57–79. https://doi.org/10.1080/01446193.2011.648947

Leendertse, W., Lenferink, S., & Arts, J. (2012). Public-Private Collaboration: How Private Involvement can Contribute to Network Performance. *Procedia - Social and Behavioral Sciences*, *48*, 2917–2929. https://doi.org/10.1016/j.sbspro.2012.06.1260

Lenferink, S., Arts, J., Tillema, T., van Valkenburg, M., & Nijsten, R. (2012). Early Contractor Involvement in Dutch Infrastructure Development: Initial Experiences with Parallel Procedures for Planning and Procurement. *Journal of Public Procurement*, *12*(1), 1–42. Retrieved from https://search.proquest.com/docview/1002352955?pq-origsite=gscholar

Linstone, H. A. (1985). The Delphi Technique. In *Environmental Impact Assessment, Technology Assessment, and Risk Analysis* (pp. 621–649). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-70634-9_22

Love, P., Davis, P. R., Edwards, D. J., & Baccarini, D. (2008). UNCERTAINTY AVOIDANCE: PUBLIC SECTOR CLIENTS AND PROCUREMENT SELECTION, *21*(7), 753–776.

Love, P., Edwards, D. J., & Irani, Z. (2012). Moving beyond optimism bias and strategic misrepresentation: An explanation for social infrastructure project cost overruns. *IEEE Transactions on Engineering Management*, *59*(4), 560–571. https://doi.org/10.1109/TEM.2011.2163628

Love, P., O'Donoghue, D., Davis, P. R., & Smith, J. (2014). Procurement of public sector facilities. *Facilities*, *32*(9/10), 460–471. https://doi.org/10.1108/F-03-2012-0020

Meadows, D. (2009). *Thinking in Systems*. Vermont: Chelsea Green Publishing. Retrieved from https://books.google.nl/books?hl=nl&lr=&id=CpbLAgAAQBAJ&oi=fnd&pg=PR9&dq=thinking+in+systems+meadows+book&ots=LzkerbuAV1&sig=OfhlzgCFk9Llc6BB8S5Cz--H178#v=onepage&q=thinking in systems meadows book&f=false

Meeus, J., & Schoorl, J. (2004). Bedrijven erkennen bouwfraude - Binnenland - Voor nieuws, achtergronden en columns. Retrieved March 20, 2018, from https://www.volkskrant.nl/binnenland/bedrijven-erkennen-bouwfraude~a691728/

Mosey, D. (2009). *Early Contractor Involvement in Building Procurement: Contracts, Partnering and Project Management*. *Early Contractor Involvement in Building Procurement: Contracts, Partnering and Project Management*. Ames, Iowa. https://doi.org/10.1002/9781444309867

Mosey, D. (2014). PROJECT PROCUREMENT AND DELIVERY GUIDANCE Using Two Stage Open Book and Supply Chain Collaboration, 62.

NEC. (2016). Early Contractor Involvement. NEC. Retrieved from https://www.neccontract.com/getmedia/9c65871f-bfae-405e-9769-13f7627014c5/NEC_ECI_Jan2016-Web.pdf.aspx

Overkleeft, M. (2017). *Procuring Innovative Solutions in the Dutch Construction Industry - A Guide to Facilitate Innovation in the Procurement Process.* TU Delft.

Pawlowski, S. D., & Okoli, C. (2004). The Delphi Method as a Research Tool : An Example , Design Considerations and Applications. *Information & Management*, *42*(1), 15–29. https://doi.org/10.1016/j.im.2003.11.002

Pianoo. (2018). Pianoo - Expertisecentrum Aanbesteden |. Retrieved March 9, 2018, from https://www.pianoo.nl/

Powell, C. (2003). The Delphi Technique: myths and realities. *Methodological Issues in Nursing Research*, *41*(4), 376–382. https://doi.org/10.1046/j.1365-2648.2003.02537.x

Rahman, M., & Alhassan, A. (2012). A contractor's perception on early contractor involvement. *Built Environment Project and Asset Management*, *2*(2), 217–233. https://doi.org/10.1108/20441241211280855

Rahmani, F., Khalfan, M. M. A., & Maqsood, T. (2013). The use of early contractor involvement in different countries. *AUBEA Proceeding Conference*, 1–10. Retrieved from https://www.library.auckland.ac.nz/external/finalproceeding/Files/Papers/46530final00139.pdf

Richmond, B. (1994). System Dynamics/Systems Thinking: let's just get on with it. *International System Dynamics Conference*, 25. https://doi.org/10.1002/sdr.4260100204

Rijkswaterstaat. (2009). *Monitor Nieuwe Marktbenadering/Vervlechting 2009*.

Rijkswaterstaat. (2014). Positieve ervaringen met Plan, Design & Construct | Rijkswaterstaat. Retrieved May 14, 2018, from https://www.rijkswaterstaat.nl/over-ons/nieuws/nieuwsarchief/p2014/12/Positieve-ervaringen-met-Plan-Design--Construct.aspx

Sackman, H. (1975). *Delphi Critique*. Lexington Books.

Samenwerkingsverband opdrachtgeversforum in de bouw en Bouwend Nederland. (2016). Marktvisie - Leidende principes voor een betere samenwerking tussen opdrachtgever en opdrachtnemer.

Scheepbouwer, E., & Humphries, A. B. (2011). Transition in Adopting Project Delivery Method with Early Contractor Involvement. *Transportation Research Record: Journal of the Transportation Research Board*, *22*(28), 44–50. https://doi.org/10.3141/2228-06

Schmidt, R. (1997). Managing Delphi Surveys Using Nonparametric Statistical Techniques. *Decision Sciences*, *28*(3), 763–774. https://doi.org/10.1111/j.1540-5915.1997.tb01330.x

Schoenmaker, R., & Verlaan, J. G. (2017). CME2000 - CME2001 Graduation Thesis - Thesis Preparation Guideline. Delft: TU Delft.

Schoenmaker, R., Verlaan, J. G., & van den Boomen, M. (2017). CME1200 Collaborative Design and Engineering. Delft.

Song, L., Mohamed, Y., & AbouRizk, S. M. (2009). Early Contractor Involvement in Design and Its Impact on Construction Schedule Performance. *Journal of Management in Engineering*, *25*(1), 12–20. https://doi.org/10.1061/(ASCE)0742-597X(2009)25:1(12)

Spang, K. (2012). The European Infrastructure Procurement Symposium 2012 Business Area : Early Contractor Involvement Early Contractor Involvement (ECI). *Europ. Infra Proc. Symp*, *8*. Retrieved from http://netlipse.eu/media/48374/spang - early contractor involvement.pdf

Suprapto, M. (2016). *Collaborative Contracting in Projects*. TU Delft, Delft. https://doi.org/10.1017/CBO9781107415324.004

Thangaratinam, S., & Redman, C. W. E. (2005). The delphi technique. *The Obstetrician and*

Gynaecologist, *7*, 120–125. https://doi.org/10.1080/02688867.1988.9726654

The Dutch Construction Sector. (2016). De Marktvisie. Retrieved from http://debouwcampus.nl/co-creatie-lab/vernieuwingsagenda/item/marktvisie

van den Berg, M. A. M. C. (2007). *Mr. C. Asser's Handleiding tot beoefening van het Nederlands... (2007) | www.narcis.nl*. Tilburg: Tilburg University. Retrieved from https://www.narcis.nl/publication/RecordID/oai:tilburguniversity.edu:publications%2Fec7b65f2-4c4a-4b21-952d-1061bd7f7436

van Huuksloot, C. C. Van. (2014). Possibilities for early contractor involvement in infrastructure projects in the Netherlands, 0–84.

van Valkenburg, M., Lenferink, S., Nijsten, R., & Arts, J. (2008). Early Contractor Involvement: A New Strategy for 'Buying The Best' in Infrastructure Development in The Netherlands. In *Third International Public Procurement Conference* (pp. 1–31). Retrieved from http://www.ippa.org/IPPC3/Proceedings/Chaper 22.pdf

Wondimu, P. A., Hailemichael, E., Hosseini, A., Lohne, J., Torp, O., & Lædre, O. (2016). Success Factors for Early Contractor Involvement (ECI) in Public Infrastructure Projects. In *Energy Procedia* (Vol. 96, pp. 845–854). Elsevier. https://doi.org/10.1016/j.egypro.2016.09.146

Wondimu, P. A., Hosseini, A., Lohne, J., Hailemichael, E., & Lædre, O. (2016). Early Contractor Involvement in Public Infrastructure Projects. In *24th Annual Conference of the International Group for Lean Construction* (pp. 13–22). Boston. Retrieved from https://www.researchgate.net/profile/Ali_Hosseini39/publication/305699322_Early_Contractor_Involvment_In_Public_Infrastructure_Projects/links/581ad87e08ae3c82664c3da3/Early-Contractor-Involvment-In-Public-Infrastructure-Projects.pdf

Appendix A – System Approach

Systems thinking as described in the *Methodology* chapter shows the way the systems thinking works. By finding the elements and their relations, a systematic representation of construction project was created. This systematic representation as found in the *Scoping Round* chapter was built up from the elements and their relations identified during a brainstorm with colleagues and an expert, Sander Jacobs. The list of elements is created with the intention to fit most public construction projects. This appendix shows the list of elements and the subsystems for each relevant life cycle phase in the following figures:

- Figure 30: List of elements per life cycle phase
- Figure 31: Subsystem Initiation Phase
- Figure 32: Subsystem Planning and Design Phase
- Figure 33: Subsystem Construction

It must be noted that the representation of certain elements has been subject to reformulation and comments from both consulted experts and the graduation committee. For the sake of time, the iterations are done exclusively on the highest-level system models.

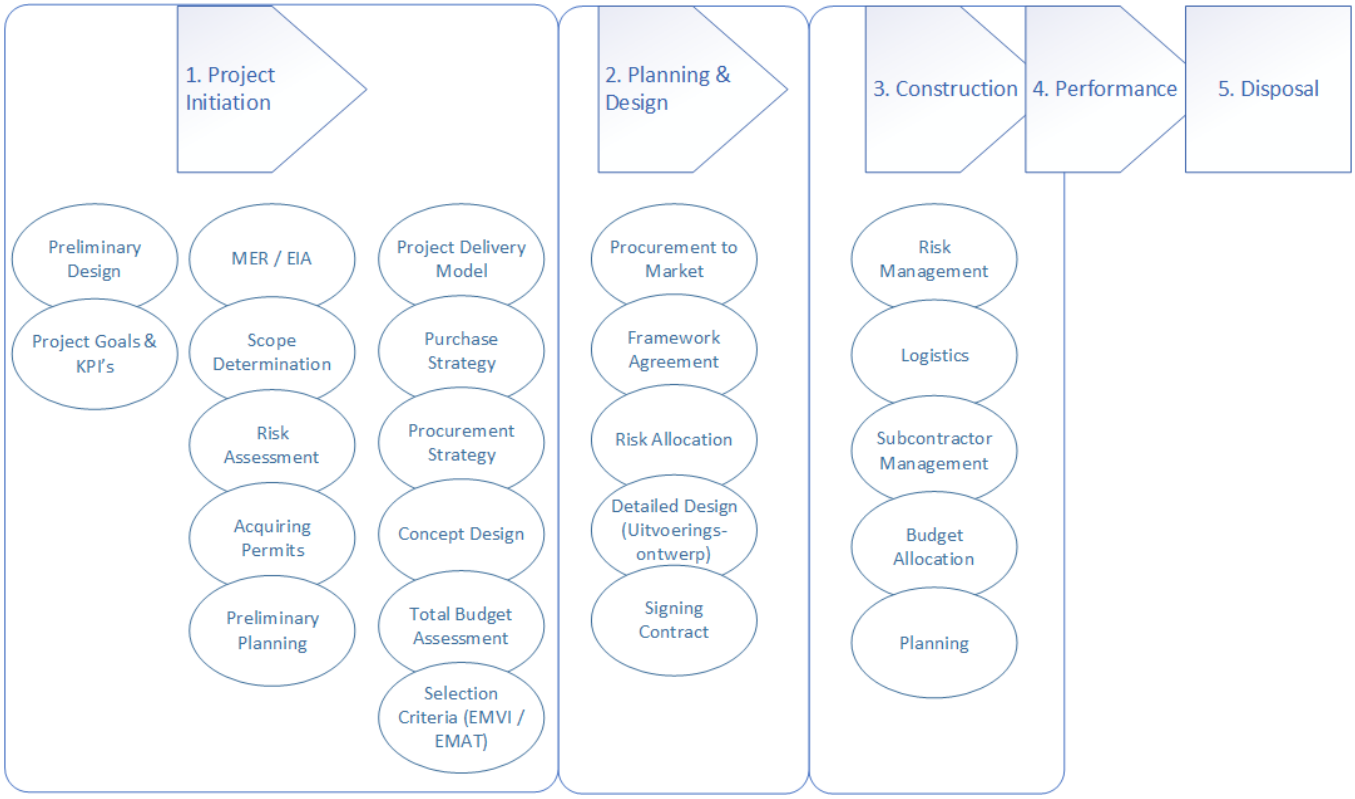


Figure 30: Elements per life cycle phase

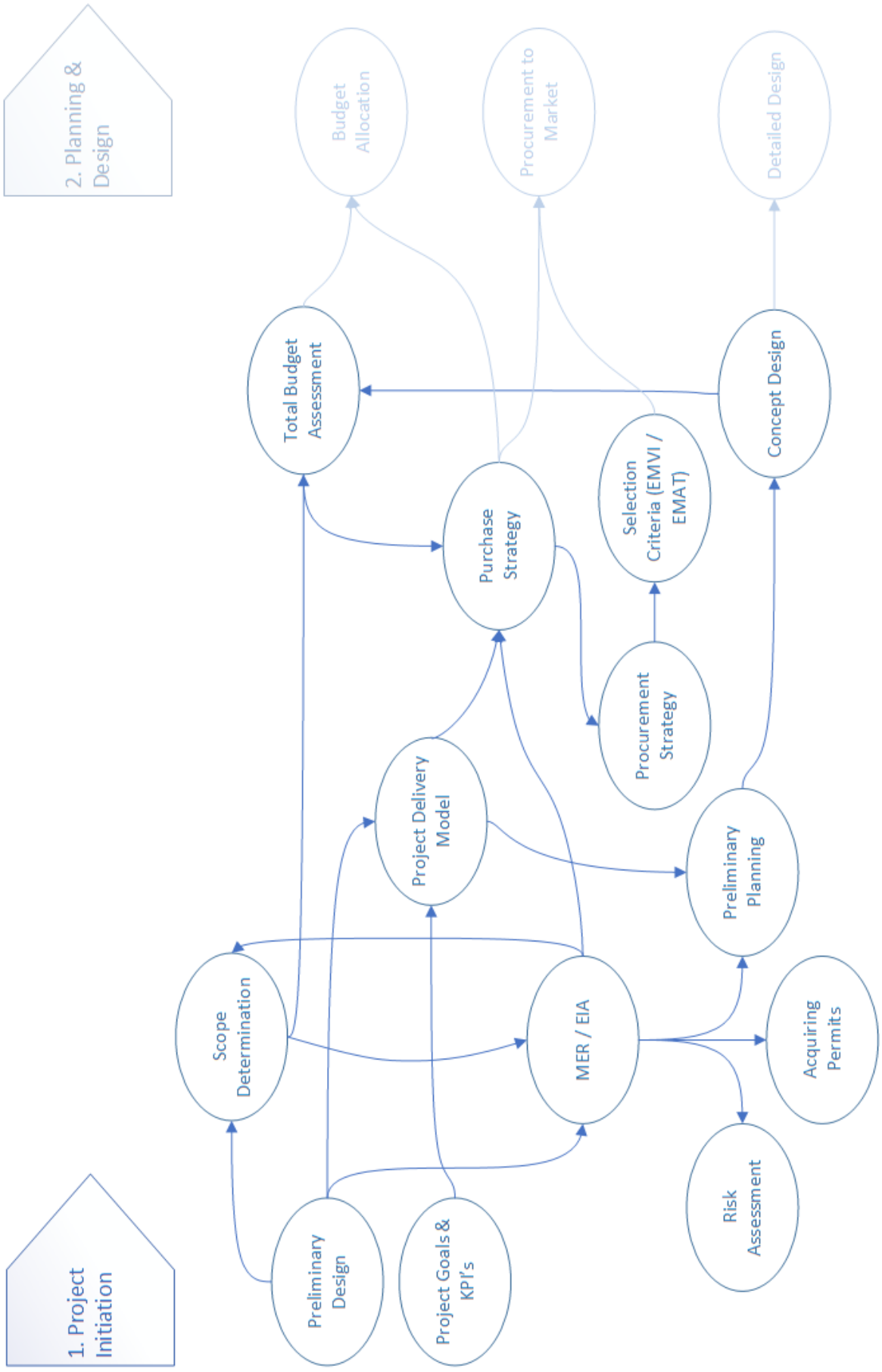


Figure 31: Subsystem Initiation Phase

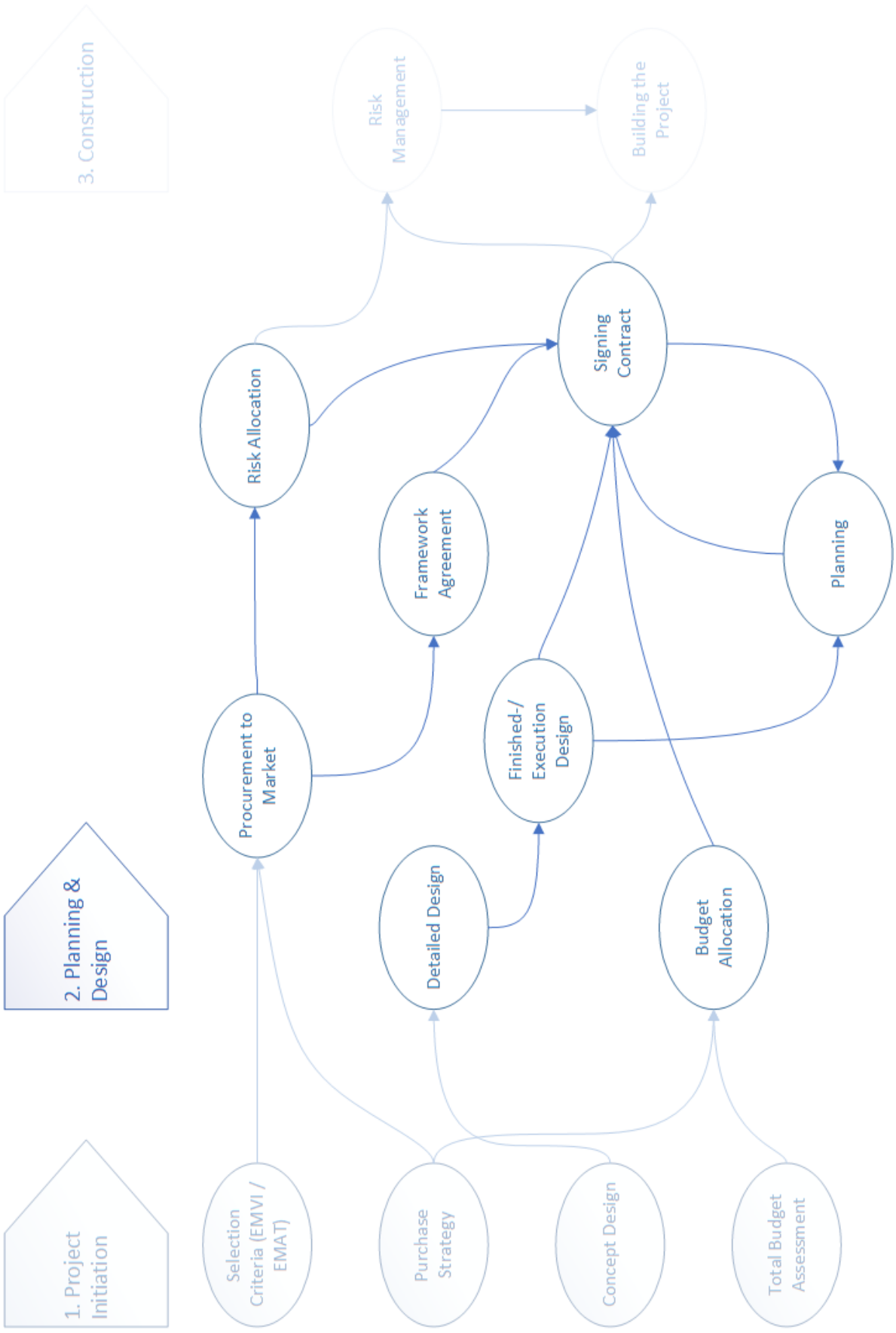


Figure 32: Subsystem Planning & Design Phase

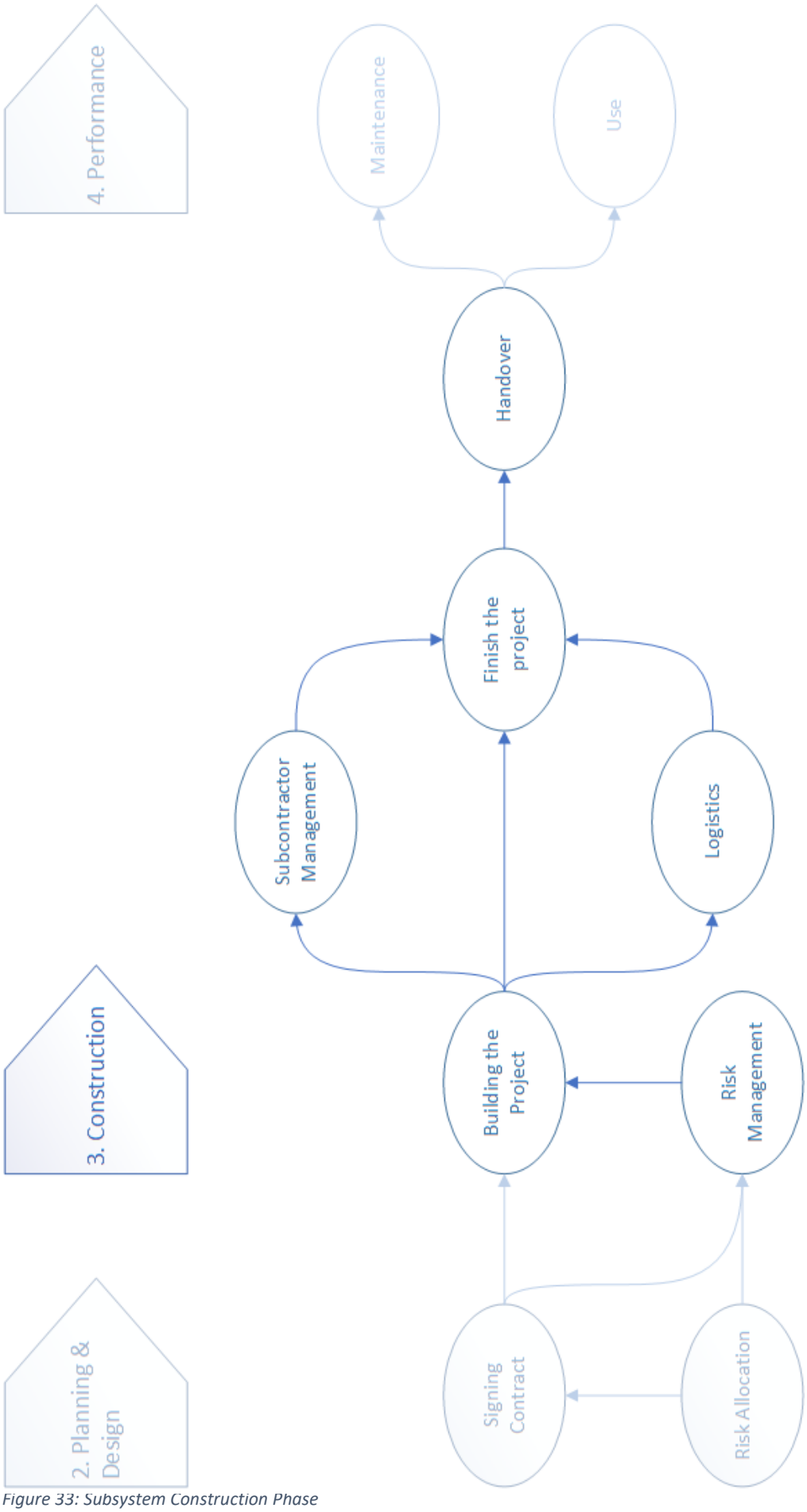


Figure 33: Subsystem Construction Phase

Appendix B – Interview Questions (Delphi Round 1)

The interviews are conducted in Dutch

Welkom; introductie interview; vragen of opnemen ok is!

1. Zou u uzelf even kunnen introduceren (naam, rol (nu en eerder), ervaring)?
2. Wat verstaat u onder Early Contractor Involvement?
    a. Indien niet genoemd, waar is het in de praktijk aan te linken?
3. Wat zijn de essentiële onderdelen die deze methode onderscheiden van andere samenwerkingsvormen?
4. Doen we in uw ogen in Nederland al aan ECI? Kunt u voorbeelden noemen?
    a. Zo ja, waar en hoe? Zo niet, waarom niet?
5. Wat zijn naar uw mening de voordelen van ECI als samenwerkingsvorm?
    a. In hoeverre zijn deze gebaseerd op feiten/Zijn deze voordelen realistisch?
    b. Op welk aspect van het bouwen hebben deze effect?
    c. Aan welke factoren ligt dat? (contractvormen, vertrouwen, communicatie)
    d. Welke partijen hebben hier specifiek voordeel van (opdrachtgever, aannemer, ontwerper etc)?
6. Wat zijn naar uw mening de nadelen van ECI?
    a. In hoeverre zijn deze gebaseerd op feiten/Zijn deze nadelen realistisch?
    b. Op welk aspect van het bouwen hebben deze effect?
    c. Aan welke factoren ligt dat? (contractvormen, vertrouwen, communicatie)
    d. Welke partijen hebben hier specifiek nadeel van (opdrachtgever, aannemer, ontwerper etc)?
    e. Hoe zouden partijen ECI kunnen misbruiken?
7. Welke barrières of condities ziet u voor de verdere implementatie van ECI?
    a. Zijn er incentives die deze barrières kunnen slechten?
    b. Is de huidige vorm van ECI voldoende om het potentieel van ECI te benutten? En zo ja, hoe? Zo niet, waarom niet?
    c. Zijn er bepaalde partijen die hier specifiek een rol in zouden kunnen spelen?
8. Heeft u ook zicht op ECI ervaringen in het buitenland?
    a. Zo ja, waar en in hoeverre verschilt dit van Nederland en waarom?

Heb ik nog iets gemist of wilt u nog iets toevoegen?

Afsluiten & Bedanken; benadrukken belang digitale vragenlijsten

DOEL 1: Definitie van ECI

DOEL 2: Voordelen van ECI identificeren

DOEL 3: Manier vinden om deze voordelen te halen

Appendix C – Digital Questionnaire 1 (Delphi Round 2)

The questionnaires are conducted in Dutch

The questionnaires are conducted in Google Forms, with the use of randomizing the orders of possible answers and the use of mandatory and not-mandatory questions. Google Forms also allowed using sections and conditional links to improve the practicality of the questionnaire. For more information, contact the researcher (info at the beginning of this thesis).

Beste Experts,

Nu de interviews voltooid zijn is het tijd voor de volgende stap in mijn onderzoek. Deze vragenlijst is de eerste van twee soortgelijke vragenlijsten. Het doel van deze vragenlijsten is tweeledig; ten eerste dient het tot validatie van de eerdere antwoorden die gegeven zijn, en ten tweede dienen ze om de mate van consensus te meten over de verschillende aspecten van Early Contractor Involvement (ECI). Dit laatste is het belangrijkste onderdeel van deze vragenlijsten. Op basis van de antwoorden die in overeenstemming zijn zal het uiteindelijke advies over ECI gebaseerd zijn.

De vragenlijst is zo ingericht dat het invullen ervan maximaal een half uur in beslag zal nemen, maar mijn verwachting is dat dit veel minder zal zijn. De deadline voor het invullen van de vragenlijst is 21 mei, 12:00.

De antwoorden worden geanonimiseerd tot perspectief (publieke opdrachtgever, aannemer of ingenieursbureau). Dit zal overeenkomen met hoe de antwoorden in deze vragenlijst zijn weergegeven. De uiteindelijke resultaten van het onderzoek worden op gelijkwaardige wijze geanonimiseerd en zullen worden teruggekoppeld vóór de publicatie van het onderzoek. Dit moment zal zijn na afsluiting van de tweede ronde van de vragenlijsten.

Ik raad u aan de vragenlijst in 1 keer helemaal in te vullen. Bij verschillende vragen bestaat de mogelijkheid om extra toelichting te geven, maar dit is niet verplicht. Aan het einde van de vragenlijst is er ruimte voor vragen en/of opmerkingen over de vragenlijst of over het onderzoek.

Ontzettend bedankt voor uw respons!

Met vriendelijke groet,

Dirk van Wijck

1. Wat is uw naam?
2. Welke onderdelen zijn naar uw mening essentieel voor de definitie van ECI? (Meerdere antwoorden mogelijk)
    a. De planvormingsfase
    b. Een contractuele overeenkomst
    c. Samen het contract opstellen
    d. Marktconsultatie
    e. Expertise van de aannemer betrekken
    f. Anders, namelijk…
3. Welke van de volgende bestaande vormen ziet u als ECI? (Meerdere antwoorden mogelijk)
    a. Allianties
    b. Vervlechting
    c. Aanbesteding met dialoog
    d. Bouwteam
    e. Marktconsultatie
    f. D&C contracttypes (UAV-GC)
    g. PDC (Planuitwerking, design & construct)
    h. Anders, namelijk…
4. Zou er een nieuwe contractvorm nodig zijn om het potentieel van ECI te benutten? (Ja/nee + mogelijke toelichting)
5. Ik stel voor ECI als volgt te definiëren: “ECI is een aannemer contracteren in de planvormingsfase”. Kunt u zich hier een vinden? (ja/nee/gedeeltelijk + toelichting)
6. *Indien bovenstaand antwoord nee of gedeeltelijk:* Hoe zou u ECI willen definiëren? Ter herinnering, mijn definitie was “ECI is een aannemer contracteren in de planvormingsfase”.
7. Welke voordelen kan ECI bieden? (Meerdere antwoorden mogelijk)
    a. Er is meer ontwerpvrijheid voor de aannemer, waarmee de creativiteit van de aannemer beter benut wordt
    b. Betere proceskwaliteit
    c. Betere projectkwaliteit
    d. Tijdswinst
    e. Kostenbesparingen
    f. Betere uitvoerbaarheid van het project
    g. Een meer realistische kosteninschatting
    h. Een meer realistische planning
    i. Betere risico-inschatting
    j. Betere risico-verdeling
    k. Betere projectbeheersing
    l. Lagere transactiekosten
    m. Anders, namelijk…
8. Welke nadelen brengt ECI met zich mee? (Meerdere antwoorden mogelijk)
    a. Er is ruimte voor strategisch/opportunistisch gedrag
    b. Het is relatief meer werk voor de betrokken partijen
    c. Het vereist een bepaald denkniveau van de betrokken personen
    d. Een vroege contractuele relatie beperkt de flexibiliteit van de opdrachtgever
    e. De marktwerking/competitie wordt minder
    f. Voornamelijk de grote aannemers zullen in aanmerking komen voor deze contracten, wat ten nadele is van kleinere aannemers
    g. De aannemer is (nog) niet in staat de adviesrol op zich te nemen

    h. In de huidige rolverdeling schuift er werk van het ingenieursbureau naar de aannemer
    i. De objectiviteit van de opdrachtgever komt meer ter discussie
    j. Anders, namelijk…
9. Zijn deze nadelen op te lossen? (Ja/nee/gedeeltelijk + toelichting)
10. Wegen de mogelijke voordelen op tegen de nadelen? (Ja/nee/dat durf ik niet te zeggen + toelichting)
11. Waar biedt ECI het meeste voordeel? (+ toelichting)
    a. Bouwprojecten met een hoge complexiteit
    b. Bouwprojecten met een lage complexiteit
    c. Maakt niet uit
    d. Anders, namelijk….
12. Welke partijen hebben het voordeel van ECI? (Meerdere antwoorden mogelijk)
    a. De opdrachtgever
    b. De aannemer
    c. Het ingenieursbureau
    d. Externe stakeholders (bijvoorbeeld bewoners uit de directe projectomgeving)
    e. Anders, namelijk…
13. Welke barrières ziet u voor de implementatie van ECI? (Meerdere antwoorden mogelijk)
    a. De transactiekosten zijn hoger voor de opdrachtgever
    b. De tenderkosten zullen hoger zijn voor de aannemer
    c. De vergoeding/compensatie voor de tenderkosten is onvoldoende
    d. Competitie waarborgen is lastig
    e. Er is angst bij de opdrachtgever voor het vroeg binden aan één aannemer
    f. Er worden te weinig projecten aanbesteed met mogelijkheden voor ECI
    g. Er is een gebrek aan doorzettingsvermogen om te experimenteren met ECI
    h. Anders, namelijk….
14. Welke condities ziet u voor de implementatie van ECI? (Meerdere antwoorden mogelijk)
    a. De huidige rolverdeling van aannemer, ingenieursbureau en opdrachtgever moet anders worden ingevuld
    b. Er zullen meer projecten aanbesteed moeten worden met ECI
    c. De aanbesteding zal specifiek voor ECI moeten worden ingericht
    d. De omgang met risico’s moet anders worden ingericht
    e. Anders, namelijk….
15. Welke incentives kunnen helpen ECI te implementeren? (Meerdere antwoorden mogelijk)
    a. Grotere vergoedingen/compensatie voor de tenderkosten van de aannemer
    b. Betere communicatie afdwingen tussen opdrachtgever en de markt
    c. Een investering vanuit de publieke sector om te experimenteren met ECI
    d. Past Performance criteria gebruiken bij de aanbesteding (vergelijkbaar met Best Value Procurement)
    e. Incentives opstellen op gedrag van de opdrachtnemers
    f. Een goede exit-clausule voorschrijven
    g. Anders, namelijk…
16. Welke partij zou het initiatief moeten nemen voor de implementatie van ECI? (+ toelichting)
    a. De opdrachtgever
    b. De aannemer
    c. Alle betrokken partijen

17. Moet ECI naar uw mening meer gebruikt en ontwikkeld worden? (Ja/nee/misschien + toelichting)
18. Op welke termijn zou het potentieel van ECI benut kunnen worden? (+ toelichting)
    a. Binnen 1 jaar
    b. 1-2 jaar
    c. 2-5 jaar
    d. 5-10 jaar
    e. Langer dan 10 jaar
    f. Het potentieel van ECI zou nooit gerealiseerd kunnen worden
19. Heeft u nog vragen en/of opmerkingen?

Appendix D – Digital Questionnaire 2 (Delphi Round 3)

The questionnaires are conducted in Dutch

The questionnaires are conducted in Google Forms, with the use of randomizing the orders of possible answers and the use of mandatory and not-mandatory questions. Google Forms also allowed using sections and conditional links to improve the practicality of the questionnaire. For more information, contact the researcher (info at the beginning of this thesis).

Beste Experts,

Deze vragenlijst is de laatste in mijn onderzoek naar ECI. Het doel van deze vragenlijst is om ECI verder uit te werken en de kaders van ECI strakker neer te zetten. Dit gebeurt als volgt:

1. De antwoorden van de eerdere vragenlijst zijn als volgt beschouwd; Antwoorden die met 75% of meer overeenkomen tussen de respondenten worden aangenomen en niet verder ter discussie gesteld. Antwoorden die door 2 personen of minder gegeven worden, worden vanaf nu buiten beschouwing gelaten, tenzij deze nieuwe inzichten geven of gegeven hebben. Alles wat hier tussen valt zal nogmaals getoetst worden, al dan niet op andere wijze.

2. Voor de discussiepunten die overbleven na stap 1 is er gekeken naar de antwoordfrequenties en condities vanuit de toelichtingen op de antwoorden. Dit zal duidelijk worden in de vragenlijst, ofwel in de toelichting of in de vraag zelf.

Net als in bij de voorgaande vragenlijst en interviews zullen de antwoorden worden geanonimiseerd en worden teruggekoppeld voor publicatie. Bijgaand met de uitnodiging voor deze vragenlijst treft u de geanonimiseerde antwoorden van de eerste vragenlijst aan.

Ik raad u ook voor deze vragenlijst aan hem in 1 keer volledig in te vullen. De vragenlijst zal wederom minder dan 30 minuten tijd kosten. Ook bij deze vragenlijst bestaat bij verschillende vragen de mogelijkheid om extra toelichting te geven, maar ook hier is het (meestal) niet verplicht. Aan het einde van de vragenlijst is er ruimte voor vragen en/of opmerkingen.

Bedankt voor uw medewerking aan het onderzoek! De onderzoeksresultaten zullen dinsdagmiddag 24 juli worden gepresenteerd bij Royal HaskoningDHV in Amsterdam. Hier krijgt u tzt een uitnodiging voor.

Met vriendelijke groet,
Dirk van Wijck
dirk.van.wijck@rhdhv.com
+31650490489

1. Wat is uw naam?
2. De definitie van ECI als een contractuele relatie in de planvormingsfase is niet erkend door het expertpanel. Het commentaar hierop betrof dat ECI ook zonder contract gebruikt kan worden om de expertise van de aannemer te betrekken. Mijn voorstel is daarom als volgt; ECI opsplitsen in 2 verschillende vormen. Een contractuele vorm en een consulterende vorm. Welke definitie past het beste bij de contractuele vorm van ECI? De contractuele vorm van ECI is ...
    a. Gezamenlijk een contract opstellen in de planvormingsfase (los van de trajectbeslissing)
    b. De aannemer contracteren voor het trajectbesluit vast ligt
    c. De aannemer contracteren zodra het trajectbesluit vast ligt
    d. De aannemer selecteren tijdens het trajectbesluit, waarna samen het contract wordt opgesteld.
    e. Anders, namelijk…
3. Welke definitie past het beste bij de consulterende vorm van ECI? De consulterende vorm van ECI is…
    a. Het consulteren van een aannemer voor een werk wordt aanbesteed of een uitrvraag wordt gedaan
    b. Een marktconsultatie
    c. Anders, namelijk…
4. Zou het potentieel van ECI benut kunnen worden in de volgende bestaande vormen? (per rij 1 antwoord mogelijk)

	Ja	Gedeeltelijk	Nee
PDC (plan, design, construct)			
Vervlechting			
Bouwteam			

5. Ziet u mogelijkheid tot implementatie van ECI in de volgende bestaande contractvormen? (per rij 1 antwoord mogelijk)

	Ja	Nee	Ja, maar dit vereist kleine aanpassingen
UAV-GC			
UAV (Traditioneel)			
Nieuwe contractvorm			

6. In welke vorm zou het potentieel van ECI het beste benut kunnen worden?
    a. PDC (plan, design, construct)
    b. Vervlechting
    c. Bouwteam
    d. Er is een nieuwe samenwerkingsvorm nodig
7. Wilt u dit toelichten?
8. In hoeverre verwacht u de volgende voordelen terug te zien bij ECI? *De antwoorden zijn geordend in de mate waarin ze geantwoord zijn in de eerste vragenlijst.*

	Altijd	Vaak	Alleen in specifieke gevallen	Nooit
Betere risicoverdeling				
Een meer realistische kosteninschatting				

Er is meer ontwerpvrijheid voor de aannemer, waardoor de creativiteit van de aannemer beter wordt benut				
Betere uitvoerbaarheid van het project				
Een meer realistische planning				
Kostenbesparingen				
Betere risicoinschatting				
Betere projectkwaliteit				
Tijdswinst				
Betere proceskwaliteit				

9. Ziet u voordelen van ECI ten opzichte van de volgende bestaande samenwerkingsvormen? *Kruis per potentieel voordeel aan of u een voordeel ziet van ECI ten opzichte van welke bestaande samenwerkingsvormen. Dus als u denkt dat ECI voor een verbeterde risicoverdeling zorgt dan D&C en allianties, dan kruist u D&C en allianties aan.*

	D&C projecten	Bouwteams	Vervlechting	Allianties	PDC's	Geen van deze vormen
Betere risicoverdeling						
Een meer realistische kosteninschatting						
Er is meer ontwerpvrijheid voor de aannemer, waardoor de creativiteit van de aannemer beter wordt benut						
Betere uitvoerbaarheid van het project						
Een meer realistische planning						
Kostenbesparingen						
Betere risicoinschatting						
Betere projectkwaliteit						
Tijdswinst						
Betere proceskwaliteit						

10. Wilt u dit toelichten?
11. In hoeverre verwacht u de volgende nadelen terug te zien bij ECI? *De antwoorden zijn geordend in de mate waarin ze geantwoord zijn in de eerste vragenlijst.*

	Altijd	Vaak	Alleen in specifieke gevallen	Nooit
Problematische beperking van de flexibiliteit van de opdrachtgever				
Verliezen van de mogelijke voordelen door een onvoldoende denkniveau bij de betrokken personen				
Er is meer ontwerpvrijheid voor de aannemer, waardoor de creativiteit van de aannemer beter wordt benut				
Kleine aannemers verliezen een deel van hun marktaandeel door ECI				
Het ontstaan van problemen door strategisch- of opportunistisch gedrag				
Het is meer werk voor de betrokken partijen				
Aannemers zijn (nog) niet in staat de bijbehorende rol goed te vervullen				

12. Ziet u nadelen van ECI ten opzichte van welke bestaande samenwerkingsvormen?
Kruis per potentieel nadeel aan of u een nadeel ziet van ECI ten opzichte van welke bestaande samenwerkingsvormen. Dus als u denkt dat ECI voor meer problematische beperking van de flexibiliteit van de opdrachtgever zorgt bij Bouwteams en PDC's, dan kruist u Bouwteams en PDC's aan.

	D&C projecten	Bouwteams	Vervlechting	Allianties	PDC's	Geen van deze vormen
Problematische beperking van de flexibiliteit van de opdrachtgever						
Verliezen van de mogelijke voordelen door een onvoldoende denkniveau bij de betrokken personen						
Er is meer ontwerpvrijheid voor de aannemer, waardoor de creativiteit van de aannemer beter wordt benut						
Kleine aannemers verliezen een deel van hun						

marktaandeel door ECI						
Het ontstaan van problemen door strategisch- of opportunistisch gedrag						
Het is meer werk voor de betrokken partijen						
Aannemers zijn (nog) niet in staat de bijbehorende rol goed te vervullen						

13. Wilt u dit toelichten?
14. Welke incentives kunnen deze barrières mogelijk slechten? *De barrières zijn geordend aan de hand van de reacties op de vorige vragenlijst*

	Een investering vanuit de publieke sector	Een goede exit-clausule	Past Performance criteria zoals bij BVP	Incentives opstellen op gedrag van opdrachtnemers
Barrière 1: Er is angst bij de opdrachtgever voor het vroeg binden aan één aannemer				
Barrière 2: Er is een gebrek aan doorzettingsvermogen om te experimenteren met ECI				
Barrière 3: Competitie waarborgen is lastig				

15. Uit de vorige questionnaire kwam naar voren dat er 4 condities zijn voor het implementeren voor ECI. Welke conditie(s) ziet u als minimumeis voor het gebruik van ECI? Meerdere antwoorden zijn mogelijk. *De volgorde van de antwoorden is gebaseerd op de antwoordfrequentie uit de vorige vragenlijst*.
    a. De huidige rolverdeling van aannemer, ingenieursbureau en opdrachtgever moet anders worden ingedeeld
    b. De omgang met risico's moet anders worden ingericht
    c. De aanbesteding zal specifiek voor ECI moeten worden ingericht
    d. Er zullen meer projecten moeten worden aanbesteed met ECI
    e. Anders, namelijk…
16. Welke factoren voor een project bepalen de geschiktheid voor het gebruik van ECI? Meerdere antwoorden zijn mogelijk.
    a. Technische complexiteit
    b. Nieuwe technieken/materialen toepassen
    c. Omgeving met veel verschillende stakeholders

d. Specifieke risico’s
e. Complexe ruimtelijke inpassing
f. Anders, namelijk…

Praktische extra vragen: Uit de toelichting van de verschillende antwoorden en discussies over het onderzoek zijn nog een aantal vragen naar voren gekomen. Deze vragen hebben als doel de resultaten te nuanceren.

17. De 'Contractor' in ECI refereert letterlijk naar de aannemer. De vraag is of dit de beste invulling is. Zou het ingenieursbureau ook gevat kunnen worden onder deze definitie? (ja/nee)
18. Wilt u dit toelichten?
19. In de antwoorden van de interviews en eerste vragenlijst wordt er gesproken over een 'bepaald vereist denkniveau' voor de toepassing van ECI. Wat wordt hiermee bedoeld?
20. Hoe verwacht u dat de toekomst van ECI eruitziet voor publieke constructieprojecten? (Niet verplicht!)

    Afsluiting: Hartelijk bedankt voor uw deelname aan dit onderzoek!
21. Heeft u nog vragen en/of opmerkingen?

Appendix E – Confirmation of the Results

The confirmation session was conducted in Dutch

ECI kan op 2 manieren gedefinieerd worden;

- Een consulterende vorm (Marktconsultatie) Oneens – Beetje oneens – Beetje eens – **Eens**
- Een contracterende vorm (+uitleg) Oneens – Beetje oneens – Beetje eens – **Eens**

In Nederland wordt al aan ECI gedaan Oneens – Beetje oneens – Beetje eens – **Eens**

PDC, Bouwteam en Vervlechting zijn vormen waar ECI al in gebruikt wordt.
Oneens – Beetje oneens – Beetje eens – **Eens**

ECI zou toegepast kunnen worden in de UAV-GC Oneens – Beetje oneens – Beetje eens – **Eens**

Een nieuw contracttype zou het beste zijn voor ECI Oneens – Beetje oneens – Beetje eens – **Eens**

Het potentieel van ECI wordt niet benut Oneens – Beetje oneens – Beetje eens – **Eens**

De voordelen van early contractor involvement zijn:

- Een meer realistische kosteninschatting Oneens – Beetje oneens – **Beetje eens** – Eens
  Aannemers kunnen al veel vroeg vastleggen, de vraag is of dit de bedoeling is
- Een betere risicoverdeling Oneens – Beetje oneens – Beetje eens – **Eens**
- Meer ontwerpvrijheid voor de aannemer Oneens – Beetje oneens – Beetje eens – **Eens**
  Moet wel benut worden!
- Betere uitvoerbaarheid van het project Oneens – Beetje oneens – **Beetje eens** – Eens
- Een meer realistische planning Oneens – Beetje oneens – **Beetje eens** – Eens
- Hogere uiteindelijke projectkwaliteit Oneens – Beetje oneens – **Beetje eens** – Eens
- Een kostenvermindering Oneens – **Beetje oneens – Beetje eens** – Eens
  Alleen als dit het doel is; ECI biedt ook meerwaarde indien een project beter is voor meer geld.
- Een betere risico-inschatting Oneens – Beetje oneens – **Beetje eens** – Eens

De nadelen van ECI zijn

- Een vroege contractuele relatie tussen de klant en één aannemer limiteert de flexibiliteit van de klant. Oneens – **Beetje oneens** – Beetje eens – Eens
  Project specifiek en kan zo ingericht worden dat dit niet het geval is.
- ECI vereist een bepaald denkniveau Oneens – Beetje oneens – Beetje eens – **Eens**

De voordelen van ECI zijn voornamelijk voor de opdrachtgever en de aannemer
Oneens – **Beetje oneens** – Beetje eens – Eens
Externe stakeholders zouden het meeste voordeel moeten hebben, gezien de publieke opdrachtgever het werk voor hen onderneemt.

De nadelen van ECI zijn voornamelijk voor de opdrachtgever
Oneens – Beetje oneens – Beetje eens – Eens
Met een goeie inrichting en exit-clausule is dit niet aan de orde.

ECI biedt het meeste voordeel t.a.v. D&C projecten Oneens – Beetje oneens – Beetje eens – **Eens**

De condities voor implementatie van ECI zijn

- De rolverdeling van ingenieursbureau, opdrachtgever en aannemer moet anders
  Oneens – Beetje oneens – Beetje eens – **Eens**
- De risicoverdeling moet anders Oneens – Beetje oneens – Beetje eens – **Eens**

- De aanbesteding moet specifiek voor ECI worden ingericht
  Oneens – Beetje oneens – Beetje eens – **Eens**

De barrières voor ECI zijn

- De opdrachtgever is bang voor de beperking in de flexibiliteit door de vroege contractuele relatie met één aannemer Oneens – Beetje oneens – Beetje eens – **Eens**
- Er is een gebrek aan doorzettingsvermogen om te experimenteren met ECI en het verder te ontwikkelen Oneens – Beetje oneens – Beetje eens – **Eens**
- Het is lastig om de marktwerking te waarborgen met ECI
  Oneens – Beetje oneens – Beetje eens – Eens
  Wederom afhankelijk van de inrichting.

Deze barrières kunnen opgelost worden door deze incentives

- Een investering vanuit de publieke sector om te experimenteren met ECI
  Oneens – Beetje oneens – Beetje eens – **Eens**
  Kanttekening hier is dat het gaat om onderzoek voor de voorbereiding van een project met ECI en het evalueren en LEREN tijdens het project en volgende projecten.
- Een goed ingevulde exit-clausule om de contractuele overeenkomst te kunnen beëindigen moet beschikbaar zijn Oneens – Beetje oneens – Beetje eens – **Eens**

- Het gebruik van Past-Performance criteria voor het aanbesteden van projecten met ECI
  Oneens – Beetje oneens – Beetje eens – Eens
  Zo ver zijn we nog niet
- Het gebruik van incentives op basis van gedrag van de opdrachtnemer
  Oneens – Beetje oneens – **Beetje eens** – Eens
  Moet gaan om uiting van gedrag

ECI kan het beste worden toegepast op complexe projecten
Oneens – Beetje oneens – Beetje eens – Eens
ECI kan ook zeker meerwaarde bieden bij gestandaardiseerde projecten (brug uit de catalogus).

ECI moet verder ontwikkelt en meer gebruikt worden in Nederland
Oneens – Beetje oneens – Beetje eens – **Eens**


Royal
HaskoningDHV
Enhancing Society Together
TUDelft