Mauricio David Pico Parra

Effective Inter-Organizational Collaboration for Interconnecting Infrastructures

Assessing effective integrated collaboration between infrastructure owners in the design phase of Dutch infrastructure projects

TU Delft

Effective Inter-Organizational Collaboration for Interconnecting Infrastructures

Assessing effective integrated collaboration between infrastructure owners in the design phase of Dutch infrastructure projects

By

Mauricio David Pico Parra

In partial fulfilment of the requirements for the degree of:

Master of Construction Management and Engineering (CME)

at the Delft University of Technology,
to be defended publicly on July 17, 2020 at 16:00

Thesis committee:

First supervisor:	M. Rikhtegarnezami (MSc)	TU Delft
Second supervisor:	Dr. M.L.C. de Bruijne	TU Delft
Third supervisor:	Dr. A. Ersoy	TU Delft
Chair:	Prof. Dr. H.L.M. Bakker	TU Delft

TU Delft

Preface

This thesis is the final step of the Master program "Construction Management and Engineering" (CME) at the Delft University of Technology. This study was conducted during nine months and forms part of the project "Using data streams to support the integrated design of interconnecting infrastructures" funded by the Netherlands Organization for Scientific Research (NWO).

During my studies, I have been fortunate to have incredible teachers and friends who have contributed in so many ways to my intellectual and personal development.

Many people contributed in different ways to the production of this thesis. First of all, I would like to thank my graduation committee for their guidance and support throughout the entire process. Professor Hans Bakker has been an incredible source of inspiration, and I am immensely grateful for his guidance, encouragement, understanding and patience. Mark de Bruijne has provided extremely valuable guidance. This thesis has improved a lot thanks to his penetrating questions, constructive comments, and thoughtful insights. Aksel Ersoy provided me with comments with an external perspective from the project and always gave me encouraging feedback. Maryam Rikhtegarnezami has been very helpful in my intellectual development, and her comments and suggestions have improved my arguments.

I would also like to thank to all the participants in my research, for sharing their viewpoints and insights on horizontal collaboration which made this study possible. I hope I have made justice to the richness and complexity of their experiences and stories.

Finally, I am truly grateful to my beloved family who has always been there for me during my studies and are my constant inspiration. I would like to express my love and my deepest gratitude to my wife, Ana Lucia Badillo, for her unconditional love, patience, understanding, and motivation. This thesis would not have been possible without her support and encouragement.

This thesis is dedicated to my wife and to my future daughter, Sophie.

Mauricio David Pico Parra
The Hague, July 2020

Executive Summary

Infrastructure asset managers have the increasing challenge not only to maintain efficiently the functionalities and quality of their infrastructures, but also to upgrade them for the increasing demands and to achieve added value to their assets (Hertogh, Bakker, van der Vlist, & Barneveld, 2018). Moreover, infrastructure projects in densely populated areas, such as The Netherlands, suffer from increased complexity due to interdependencies of infrastructures which impact the performance of projects (NGinfra, 2017, pp.1-3; Hertogh et al., 2018). Infrastructure operators are limited to handle such complex dependencies individually, as they need to collaborate closely with other asset owners in the entire life cycle of projects, especially in the design phase, to execute the projects successfully and add value to their infrastructures.

In this light, inter-organizational collaboration (IOC) and multi-actor perspectives are driving growing attention among management scholars and practitioners to understand the complex nature of collaborative networks (Keast & Hampton, 2007; Keung & Shen, 2013; Dietrich et al, 2010; Storm, 2018). Currently, literature on IOC has many different approaches; however, its dominant focus has been within a framework of 'problem owner' – 'problem solver' relationship or an 'owner-to-contractor' perspective. This research project is conducted from an 'owner-to-owner' perspective or a horizontal collaboration perspective. The objective of this research is to investigate the required criteria to assess levels of horizontal collaboration between infrastructure owners in the design phase of projects by identifying appropriate frameworks in literature that focuses on social relationships and interdependencies, such as collaborative network and resource dependency theories. The expected result of this research study are to deliver an Inter-organizational Collaboration Assessment Tool (ICAT) to assess their levels of horizontal collaboration. The research is guided by the following research question:

How can integrated collaboration between infrastructure owners be assessed on infrastructure projects?

To answer this research question, the research study is divided into three phases. Phase 1 consist of a theoretical exploration, where literature review is conducted with the aim to gain insights to understand how levels of inter-organizational collaboration are perceived in the body of knowledge and to develop set of criteria identified in literature that focuses on social relationships and interdependencies of infrastructure owners. Based on a systematic analysis of 20 empirical articles, a selection of five empirical-based articles and one theoretical based article are selected for in-depth content analysis and further comparison to the exploratory case studies. A collaborative assessment framework is proposed in this phase with the most relevant criteria to assess horizontal collaboration based on literature review. In phase 2, the exploratory case studies are presented, where document review and key informant interviews will be conducted to obtain in-depth insights from current practitioners and available data. The project selected are: The Zandhazenbrug, located at Muiderberg, is a railway bridge designed and built as part of a major road extension project, and The Meanderende Maas which is an integrated project of dyke reinforcement, river widening, spatial quality, and area development, located along the river Meuse between Ravenstein and Lith that has recently finished its exploration phase and is scheduled to be finished by

2028. Both projects have been selected as case studies to investigate the dynamics of horizontal inter-organizational collaboration given their different forms of complexity and interdependencies between asset managers of the Dutch infrastructure industry. Finally, phase 3 involves the development and delivery of an Inter-organizational Collaboration Assessment Tool (ICAT). The tool will provide the opportunity to practitioners to assess their current level of horizontal collaboration in infrastructure projects.

The focus of this case study will be on how infrastructure operators collaborate with each other in the design phase of projects at three levels: individual, relational and organizational level and to investigate the criteria considered necessary by practitioners for effective inter-organizational collaboration between them.

The results from the relevant literature identified 5 sets of criteria with 25 different elements as potential criteria to assess horizontal collaboration. Later, a systematic analysis of the criteria refined the list to 17 remained criteria suited to describe the context of horizontal collaboration. The criteria excluded from the list were not applicable to horizontal collaboration and others had similar definitions that were compiled into a single criterion. Later, document review and insights from experienced practitioners of the Dutch infrastructure industry allowed triangulation with different sources of information about the cases. The comparative analysis shown that 14 out of the 17 criteria of the framework were recognized as relevant and appropriate by practitioners for assessing horizontal collaboration. All criteria were rearranged by priority of relevance and broken down into sub-criteria, and indicators. The final ICAT consist of 14 criteria with 30 sub-criteria (4 individual capacity criteria with 6 sub-criteria; 6 relational capacity criteria with 15 sub-criteria; and 4 organizational capacity criteria with 9 sub-criteria). The ICAT is for participants who have experience working at infrastructure project. The people invited to participate in the ICAT should have a range of experience and include high and mid-level managers, as well as team members.

This research reveals that asset managers need the knowledge of new soft mechanisms of social and cultural collaboration to deal with the increased complexity and dependencies of their infrastructure projects. Clients need to pay attention to their collaborative capacity at three different levels: individual, relational and organizational capacity in order to improve project performance.

This study contributes to the theoretical literature on horizontal collaboration as well as to assess levels of effective integrated collaboration between clients proposing an analytical tool (ICAT). Even though the tool has been drawn from the validation and analytical generalization of theory with only two cases studies due to resources and time constrains, this project finds nevertheless that the most important criteria related to assess horizontal collaboration have been accurately included in the tool. However, as mentioned elsewhere this is the first attempt of this self-assessment tool that will need to be further developed and piloted in order to be adjusted to other projects for further validation.

"Collaboration has no hierarchy. The Sun collaborates with soil to bring flowers on the earth…"

Amit Ray

Table of Contents

List of Figures

List of Tables

1. Introduction

Efficient infrastructure services are crucial to support economic growth and to enable social cohesion of modern societies. The main challenges of many countries are to upgrade and maintain their existing infrastructure networks due to current changing demands such as climate changes, social and economic developments, and innovative technologies (Mobility and Transport EU Commission, 2019). As a case in point, in the Netherlands, the Ministry of Infrastructure and Water Management has launched a major replacement and renovation program for the countries' entire infrastructure network. The program includes investments in roads and waterways, climate, water, railways, aviation, and the development of new technologies that will allow smart and sustainable mobility for the coming future (Ministerie van Verkeer en Waterstaat, 2017). Infrastructure owners have the challenge and opportunity to efficiently maintain the functionalities and quality of their infrastructures, but also to upgrade them for the changing demands and to achieve added value from their networks (Hertogh, Bakker, van der Vlist, & Barneveld, 2018). The performance of these projects therefore depends on a series of relationships and interdependencies among multiple stakeholders throughout the whole life cycle of the project, particularly, in the front-end design phase, where valuable information from multi-client teams needs to be shared and integrated into a lists of requirements and specifications that would assure the successful completion of projects (De Ridder & Noppen, 2009). These endeavors limit individual organizations, using traditional project management approaches, in handling such dependencies individually. In turn, this has produced several inefficiencies, poor project performance and lack of innovation (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011; Flyvbjerg, 2013; Latham, 1994), Which in turn has intensified fragmentation of the construction industry due to the growing demand for differentiation and specialization, as projects grow in size and complexity (Lavikka, Smeds, & Jaatinen, 2015).

In this light, Inter-organizational collaboration (IOC) has received increasing attention in order to deal with such inefficiencies and reduce fragmentation of the construction industry and to improve project performance (Keung & Shen, 2013; Love, Irani, Cheng, & Li, 2002). However, the dominant focus of collaboration agreements has been within a framework of 'problem owner' – 'problem solver' relationship or a 'owner-to-contractor' perspective (De Ridder & Noppen, 2009; Suprapto, 2016). The relationship dynamics between asset owners, especially during the design phase of projects, have not been studied in depth by scholars, which is arguably as important as the relationship between owners and contractors for the success of projects. This has resulted in the overlooking or undermining of key performance indicators of horizontal collaboration between asset owners of interconnected infrastructures, such as information sharing, coordination, effective communication, and aligned incentives (Keast & Hampton, 2007; Keung & Shen, 2013; Dietrich et al, 2010; Storm, 2018). While important aspects of successful collaboration are formal agreements and contracts because they provide obligations towards one or more other parties (Chao-Duivis et al, 2008), other informal rules or social norms such as dealing with trust, adaptive capacity, and culture are also considered important for project success (De Ridder & Noppen, 2009; Ruijter, 2019). Moreover, reinforcing the effectiveness of collaborative networks and creating the necessary

conditions for making them an endogenous reality, are key elements for successful projects (Camarinha-Matos, Afsarmanesh, & Ollus, 2008).

Another approach that has received significant interest in order to deal with inefficiencies and fragmentation in the construction industry is the use of information technologies (IT). Several authors have argued that information technology is a key component to successful inter-agency collaboration (Gil-Garcia, 2013; Gil-Garcia & Sayogo, 2016). For instance, a study argues that in the near future we could witness the emergence of highly integrated virtual/smart states, where organizations seamlessly interact through the use of sophisticated technologies (Fountain, 2001). A smart state would be a new form of electronic governance that could have the potential to integrate and share information, processes, institutions, and physical infrastructure to offer/provide better service to citizens and communities (Gil-Garcia, 2013). However, while IT might certainly be important for improving collaboration, there are many other organizational struggles and political nature related challenges that will not automatically disappear with the use of IT (Gil-Garcia, 2013). Thus, according to Gil-Garcia (2013), improvements in IT have to go hand in hand with improvements in collaborative relationships, which in turn will lead to a truly smart state.

Above all, much of the literature seems to agree that IOC is a highly promising approach to help to solve the problems that infrastructure projects have with regards to fragmentation, complexity, and interdependencies. IOC promises several synergies across organizations and allows for better social interaction, integration, information sharing, coordination and effective communication (Keast & Hampton, 2007; Keung & Shen, 2013; Dietrich et al, 2010). However, at the same time, IOC has several challenges to overcome in its effectiveness and performance for decision makers and asset owners. Currently, there are few tools to assess IOC effectiveness (Daley, 2008; Foster-Fishman, Berkowitz, Lounsbury, Jacobson, & Allen, 2001; Suprapto, 2016), and the ones that exist are mostly focused on 'client-to-contractor' relationships, which establish mainly assessment criteria for hierarchical collaboration. Therefore, there is a critical need to develop criteria to assess levels of effective collaboration from a horizontal perspective in the infrastructure industry.

Considering this context, this research aims to investigate effective IOC between infrastructure operators on the design phase of projects, and to develop an inter-organizational collaboration tool to assess levels of effective horizontal collaboration establishing the most relevant criteria within the context of a horizontal perspective. This master thesis proceeds as follows. In Chapter 2 the research design is formulated, along with the problem statement, objectives, research questions and the designed research framework. Chapter 3 presents the theoretical exploration, along with the background and literature review related to inter-organizational collaboration and presents the proposed collaborative capacity assessment framework. Following is Chapter 4, where the case studies are presented. Chapter 5 delivers the Inter-organizational collaboration assessment tool (ICAT). Finally, Chapter 6 presents the conclusions, discussions, and recommendations for future research (see Figure 1).

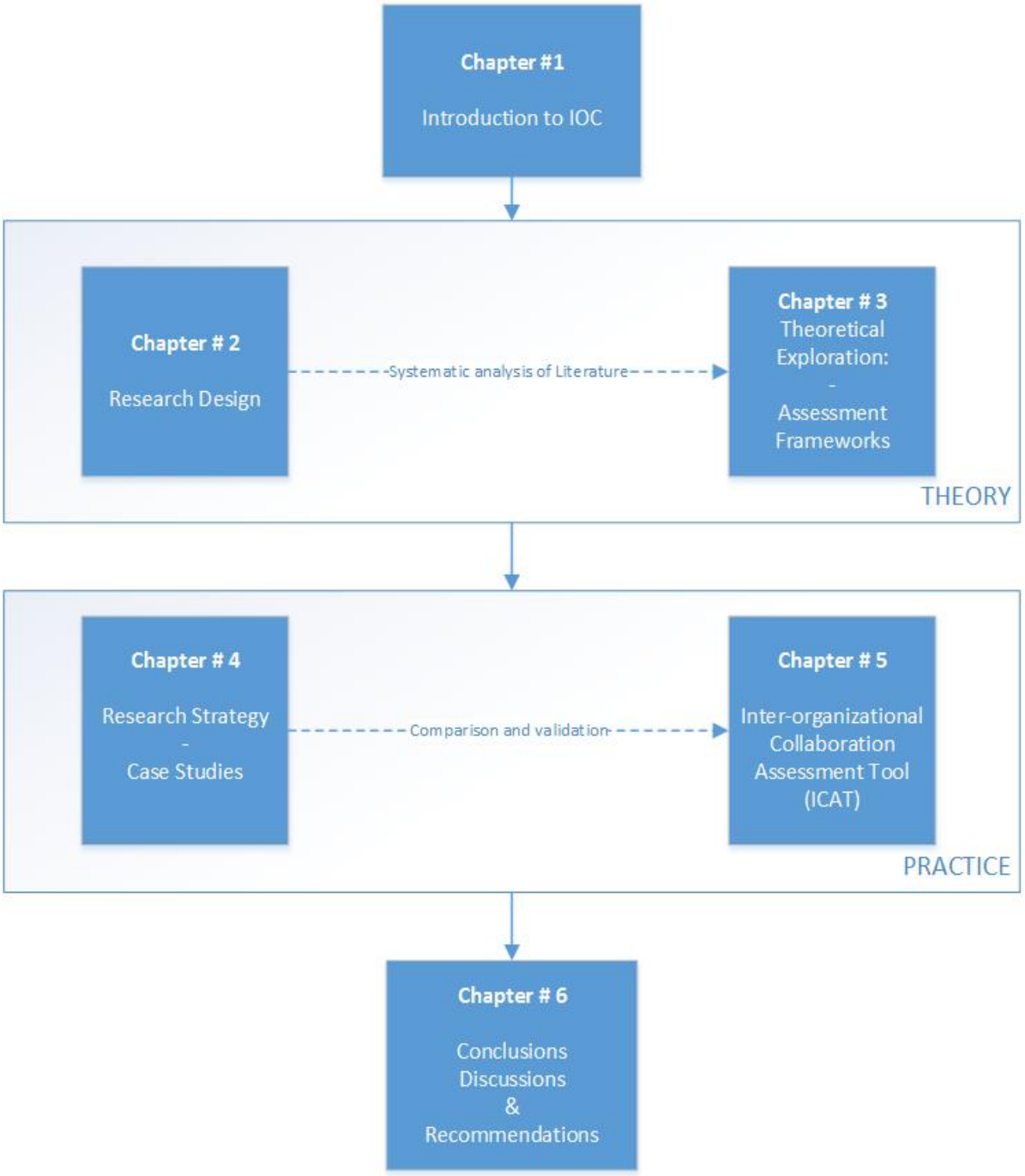

Figure 1: Outline of the Thesis

2. Research Design

2.1 Research Problem

Infrastructure asset managers are facing increased complexity in their networks, particularly on upgrading and maintaining the functionality and quality of their infrastructure networks, due to social demands, climate change, and technological developments (Hertogh et al., 2018). Moreover, in densely populated countries such as The Netherlands, there is a strong interdependency between infrastructure networks (NGinfra, 2017, pp.1-3), which according to Hertogh et al. (2018), can increase complexity and impact the performance of these replacement programs. Since, individual knowledge and resources of network operators are limited to handle such complex dependencies, they need to work together closely, especially at the design phases of infrastructure projects, in order to improve project performance and generate added value to their infrastructures (Bosch-Rekveldt et al., 2011).

In this context, inter-organizational collaboration (IOC) has received growing attention among practitioners and scholars to understand the complex nature of infrastructure projects and to improve their performance (Keast & Hampton, 2007; Keung & Shen, 2013; Dietrich et al, 2010; Storm, 2018). Storm, (2018) stresses the importance of a multi-actor perspective to investigate and manage complex projects and that actors need to recognize the different experiences, insights, and best capabilities in order to develop a joint effective strategy. Reinforcing the capacity and capabilities of collaborative networks and generating the necessary conditions for making them a reality, are key elements for successful projects (Camarinha-Matos et al., 2008). However, inter-organizational collaboration has several challenges to overcome in general with regards to its performance; challenges such as data and technological incompatibility, lack of collaborative incentives, political and power struggles (Gil-Garcia, 2013). But, before we can deal with these issues, it is important to first understand the core competencies and processes needed for successful IOC and to know how assess levels of collaboration in order to incentivize them. The collaborative capacity of network organizations is considered an important requirement to achieve successful projects (Foster-Fishman et al., 2001). Network organizations can evaluate and measure IOC through the use of collaborative capacity assessment frameworks at individual, relational, and organizational levels.

2.2 Knowledge gap

The current body of knowledge has many different approaches to study IOC, such as agency theory, transaction cost, strategic alliances, collaborative networks, and social embeddedness (Keung & Shen, 2013; Love et al., 2002; Rossignoli & Ricciardi, 2015; Suprapto, 2016). However, the dominant focus of inter-organizational relations and networks in infrastructure projects has been within a framework of 'problem owner' – 'problem solver' relationship or a 'client-to-contractor' perspective (Love et al., 2002; De Ridder & Noppen, 2009; Suprapto, 2016). And there are only a few studies that have investigated in detail the required criteria to assess levels of effective IOC, but none of them has focused on horizontal relationships. Therefore, there is a clear knowledge gap in this topic that this research project aims to fill.

2.3 Research Objectives

As large infrastructure projects face increasing levels of complex interdependencies between multiple stakeholders (Davies & Mackenzie, 2014), infrastructure operators require high levels of collaboration in order to deal effectively with such complexities and improve project performance. More specifically, the successful performance of infrastructure projects with multiple stakeholders depends greatly on levels of horizontal collaboration by means of: knowledge sharing, integration of information, and effective communication from their operators throughout the whole life cycle of projects, especially in the design phase. Therefore, infrastructure operators need to know how to assess their levels of horizontal collaboration in order to respond to continuous changing demands of their interconnecting infrastructures. In light of this context, the objective of this research is to investigate the required criteria to assess levels of horizontal collaboration between infrastructure operators in the design phase of projects by identifying appropriate frameworks in literature that focuses on social relationships and interdependencies, such as collaborative network and resource dependency theories. The expected result of this research study are to deliver an Inter-organizational Collaboration Assessment Tool (ICAT) to assess their levels of horizontal collaboration with the aim of improving project performance.

2.4 Research Questions

The following research question and sub-questions are formulated:

How can integrated collaboration between infrastructure owners be assessed on infrastructure projects?

The sub-questions that would aid answering the main question are proposed as follows:

1. What criteria to assess effective inter-organizational collaboration are currently considered in infrastructure projects?

2. How can these criteria be adjusted to analyse effective collaboration between infrastructure owners in Dutch infrastructure projects?

3. How can criteria to analyse effective inter-organizational collaboration be transformed into a collaborative assessment tool for teams from different infrastructure owners in Dutch infrastructure projects?

2.5 Research Methodology and Research Framework

This research project is an empirical study with qualitative nature that employs an exploratory case study. The research will be conducted in three phases. The first phase consists of a theoretical exploration, where literature review is conducted with the aim to gain insights to understand how levels of inter-organizational collaboration are perceived in the body of knowledge and to develop set of criteria identified in literature that focuses on social

relationships and interdependencies of infrastructure owners. The result of this first phase is a collaboration capacity assessment framework which proposes the most relevant criteria to assess levels of horizontal collaboration based on literature review. The framework will be analyzed in-depth and validated with the case studies in the next phase. The second phase involves the exploratory case studies, where document review and key informant interviews will be conducted to obtain in-depth insights from current practitioners and available data. The results from the comparison of the theoretical constructs with the analysis of the empirical insights from the case studies will validate the capacity assessment matrix and allow an analytical generalization of the criteria. The third and final phase involves the development and delivery of an Inter-organizational Collaboration Assessment Tool (ICAT). The tool will provide the opportunity to practitioners to assess their current level of horizontal collaboration in the design phase of projects (see Figure 2).

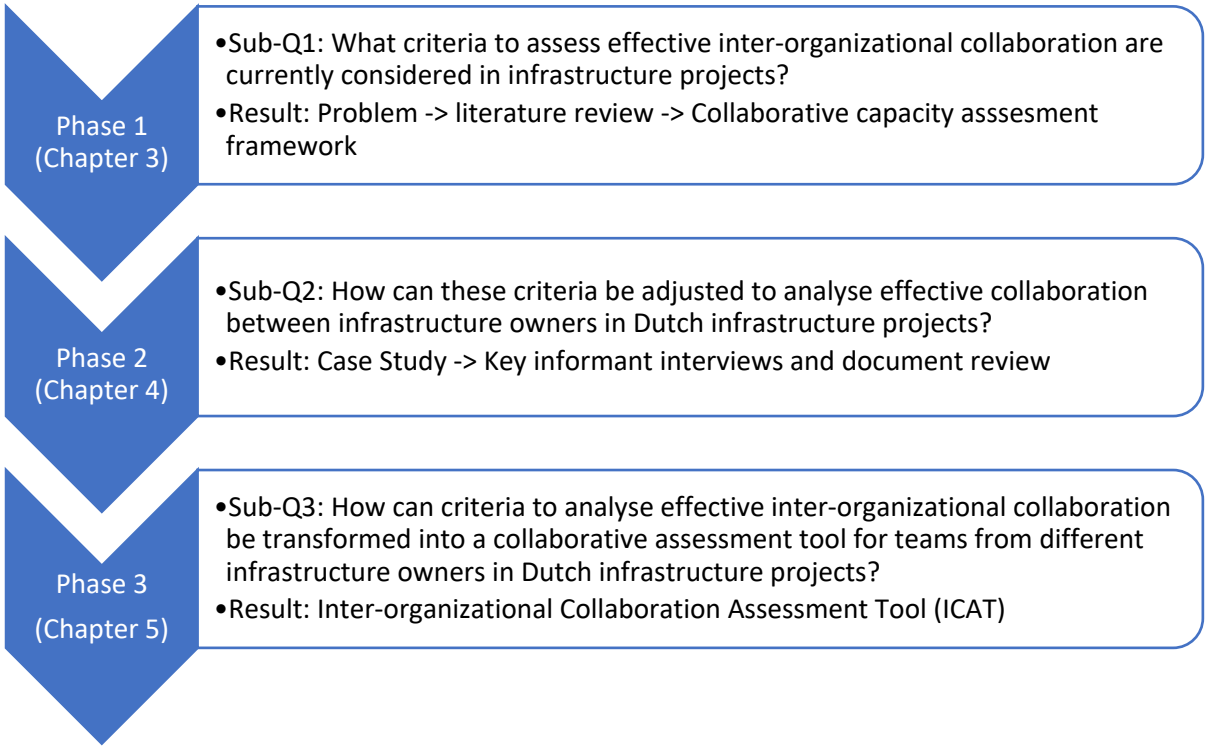

Figure 2: Research Phases, questions and results

2.6 Case Study

An exploratory case study methodology has been selected as the most suitable method for this research project due to the lack of empirical analysis in the field of IOC with a horizontal perspective between infrastructure owners. A case study can be defined as "*an empirical inquiry about a contemporary phenomenon (e.g. a case), set within its real-world context- especially when the boundaries between phenomenon and context are not clearly evident"* (Yin, 2009, p 18).

The objective of the case study is to compare the insights found in the literature review with empirical evidence of current practices in inter-organizational collaboration by Dutch infrastructure operators through document review and key-informant interviews. The infrastructure projects selected for this research study are the (1) Zandhazenbrug and the (2) Meanderende Maas. The first project, located at Muiderberg, is a railway bridge part of a large replacement program called The Schiphol-Amsterdam-Almere (SAA) Project. The second project is an integrated project of dyke reinforcement, river widening, spatial quality, and area development, located along the Meuse River, between the municipalities of Ravenstein and Lith. The projects are selected as ideal cases to investigate levels of horizontal collaboration given their variety of operators, complex dependencies (organizational, technical, and external), and with highly dynamic environments.

2.7 Key Informant interviews and document review

The focus of this case study will be on how infrastructure operators collaborate with each other in the design phase of projects at three levels: individual, relational and organizational level and to investigate the criteria considered necessary by practitioners for effective inter-organizational collaboration between them. The key informant interviews will be of a qualitative nature and semi-structured, leaving space for open-ended exploratory questions and answers in order to allow the interviewees to express their understanding of the issues involved and their own narratives regarding the sequence of events experienced. Nevertheless, the interviews will be guided by the theoretical framework developed in the first phase in order to guarantee consistency and comparability across interviews. A protocol will be provided to all interviewees 2 to 3 days before the interviews for conversation guidance and information of the research project (see Appendix A). This protocol will consist of purpose of the interview, confidentiality agreement, the research question, and a set of predetermined open-ended questions to practitioners. The interviews would generally start with an introduction of the underlying premise of the research, which is to investigate the most relevant criteria to assess levels of effective inter-organizational collaboration between infrastructure operators.

3. Theoretical Exploration

3.1 Inter-Organizational Collaboration Theories

Large engineering projects are characterized by a variety of actors, complex dependencies, and with highly dynamic environments (de Bruijn & ten Heuvelhof, 2010). Wood & Gray (1991) argue that organizations that enter into collaborative relationships to reduce complexity from their environment may suffer from more complexity and uncertainty because of the creation of new dependencies. Therefore, there is an increasing awareness of these complexities and dynamics by asset managers in engineering projects (Hertogh & Westerveld, 2010; Bosch-Rekveldt et al., 2011). Researchers have established several frameworks to understand and manage these complexities and uncertainties. For instance, Bosch-Rekveldt et al. (2011), developed a TOE (Technical, Organizational, and Environmental) framework based on a literature survey and empirical work in the process engineering industry, which can be used to assess the type of complexity of projects in order to adapt the front-end design development of projects. More specifically and with a focus on the infrastructure industry, Hertogh & Westerveld (2010) recognize two types of complexities while managing large infrastructure projects: dynamic and detail complexity, and they proposed four management approaches to deal with each combination: internal and content management, interactive management, system management, and dynamic management. Assessing the complexity of engineering projects and adjusting the management style, paves the way for asset managers to effective inter-organizational collaboration (IOC) to thrive in interconnecting infrastructure projects.

In the body of literature on IOC, many categorizations and criteria are described that could be considered to assess levels of horizontal collaboration (Kale, Singh, & Perlmutter, 2000; Keast & Hampson, 2007; Dietrich et al., 2010; Keung & Shen, 2013; Rossignoli & Ricciardi, 2015; Suprapto, 2016; Ruijter, 2019).Scholars have studied IOC in a number of ways and within different and sometimes even incompatible approaches such as agency theory, transaction cost, strategic alliances, collaborative networks, and resource dependency (Oliver & Ebers, 1998; Love et al., 2002; Rossignoli & Ricciardi, 2015). (Keung & Shen, 2013; Love et al., 2002; Rossignoli & Ricciardi, 2015; Suprapto, 2016). According to Oliver & Ebers (1998), different theoretical approaches apply to different inter-organizational relations, which mainly depend on the relationship type and interdependency between actors. For example, many scholars see inter-organizational networks in terms of the recurring ties from organizational actors (e.g. resource, friendship, informational ties) and their outcome considerations are dominated by power and control fields (Oliver & Ebers, 1998). This research study is focused on the specific context of horizontal collaboration between infrastructure owners and their interdependencies in the design phase of projects.

Within this theoretical diversity, it is important to select appropriate approaches that can consider horizontal collaboration in the infrastructure industry. Approaches such as agency theory and transaction cost theory share assumptions on economic mechanisms for managing collaborative conflicts, such as prices, fines and incentives, while considering to a lesser extend social and political mechanisms of power, bargaining and coalitions(Rossignoli & Ricciardi, 2015). While this literature brings insights to the research project, they seem to

be not particularly useful to explain the research question, especially given the absence of the consideration of horizontal relationships between infrastructure owners. For instance, agency theory is based on inter-organizational contracts that include the traditional buyer-seller relationship, which are more hierarchical processes (Rossignoli & Ricciardi, 2015).

Conversely, relational theories such as collaborative networks and resource dependency theory are characterized by their relative low importance of contracts and formal agreements and are rather based on cooperation, strong interdependencies, and pro-social mechanisms, such as reputation, flexible problem solving, knowledge sharing, mutual adaptation and trust (Rossignoli & Ricciardi, 2015). These theories are more in line with the environment and the social context that infrastructure owners operate in the design phase of projects. Therefore, these theories will be analysed in depth in the coming chapters to set of criteria to assess levels of horizontal collaboration in infrastructure projects.

3.2 Literature Review

In order to identify the main elements which assess effective IOC between infrastructure owners, a literature search was conducted using different data sources. Elsevier's Scopus was the main database as it is considered of high valued in the scientific community and offers a wider range of coverage from amongst other data sources to evaluate social sciences literature (Norris & Oppenheim, 2007). Moreover, the search was complemented with Web of Science and the search engine Google Scholar to cover other holdings and citations that could have been excluded by Scopus. The searching was based on several keyword combinations, such as 'Inter-organizational collaboration criteria', 'multi-client team collaboration', 'inter-organizational relationships', 'integrated team collaboration', 'team integration in infrastructure projects', 'network performance', 'inter-agency collaboration', 'multi-client collaboration', 'integration design processes', 'horizontal collaboration', and 'horizontal collaboration in infrastructure'. To combine these keywords, a search sensor was used such as: TITLE-ABS-KEY ("Inter-organizational collaboration criteria" AND "horizontal collaboration" OR "integrated team collaboration" OR "network performance").
The search resulted in a total of 3,000 documents, on which several filters needed to be applied in order to make the analysis more manageable. First, a filter area of engineering and social science was used to narrow down the documents that focused on engineering projects, infrastructure industry, and that cover social relational theories with the context of collaboration. The filter downsized the count to 1,150 documents. Later, the filters were limited to document type articles, and the count of documents was reduced significantly to 140 studies. Then, the search was based on the type of industry, from where the focus was placed on the infrastructure industry. The number of refereed studies were limited to those that are essential to answer the research questions and were selected based on the following criteria:

- The article includes a theoretical framework on collaborative networks.
- The article includes evaluation criteria for collaboration.
- The article addresses infrastructure industry.

Once the article fulfilled the required criteria, it was selected for a further systematic analysis. The final search resulted in a selection of five empirical-based articles and one theoretical

based article for in-depth content analysis and further comparison to the exploratory case studies (see Table 1).

After reading and doing a systematic analysis, 25 elements have been identified in the theoretical frameworks from the selected literature. The potential criteria to assess levels of collaboration between infrastructure owners are listed in Table 1. Moreover, these elements have been categorized into three essential categories in order to organize them and define meaningful relationships between infrastructure owners, further discussed in the following chapters. The categories are adapted from the work of Foster-Fisherman et al. (2001), which are: individual capacity, relational capacity and organizational capacity (see Table 2).

The concept of collaborative networks is applied to different theoretical frameworks such as joint ventures and strategic alliances. Organizations interact with each other and build strategic alliances in order to reduce uncertainty, protect interests and promote innovation (Rossignoli & Ricciardi, 2015). When forming strategic alliances, Love, et al. (2002, pp2) argue that "organizations should be aware of changes that are required in their organization such as self-governance (i.e. understanding its own capabilities); responsiveness (i.e. able to recognize changes in demand); and flexibility (i.e. able to respond changes in demand)". In the construction industry, short-term alliances are typically more common and depend mostly on the lifecycle of the project. However, a horizontal relationship between infrastructure owners can be more recognized as long-term social network with embedded social relations and interdependencies, which should be more encouraged to commit their resources to the relationship based on trust and adaptive capacity (Rossignoli & Ricciardi, 2015).

According to Kale, Singh and Perlmutter (2000), organizational literature is mainly focused on three interrelated issues in an inter-organizational relationship (IOR): the motivation for IOR formation, the choice for the governance structure of the IOR, and the effectiveness and performance of the IORs. It can be argued that the motivation for IOR formation that infrastructure owners have is related to solve several challenges that the industry currently face. Challenges that, according to Dietrich et al. (2010), come from three special characteristics of project based industries: (1) the temporally limited nature of projects, which leads to problems in establishing trust and commitment between actors, (2) the uniqueness of project transactions that can inhibit learning from projects and prevents efficiency, and (3) the complexity of the actor network which encounters different objectives from multiple partners that require to work together towards common goals. With regards to networks governance, infrastructure asset managers seem to operate in a network government mode, which, according to Keast & Hampson (2007, pp.365), its mode "is based on a social or communal organizing principle and is supported by interpersonal relational aspects such as mutual benefits and reciprocity". Finally, the last issue of effectiveness and performance of IORs is directly related to the relationship between projects outcome and the quality of collaboration between infrastructure operators for the accomplishment of common goals and successful projects. It is therefore critical to establish appropriate criteria to assess their levels of horizontal collaboration to measure their effectiveness and performance, which is the main objective of this research study.

Network study is a well-defined research approach that has been used to examine horizontal relationships among organizations, with an emphasis on the requirements of how to build and sustain these relationships (Keast & Hampson, 2007). These new arrangements require innovative strategies and processes from network actors that challenge conventional approaches and improve collaborative relationships. Collaborative networks are mainly based on informal coordination practices with low importance of contracts and formal agreements. Instead, they are mainly characterized by strong interdependencies, trust, co-adaptation, flexible problem-solving, and knowledge sharing (Rossignoli & Ricciardi, 2015). Relational management within network modes is not a top-down process based on a contract, but instead is based on a horizontal relationship focused on trust, reciprocity, and mutual benefit (Keast & Hampson, 2007).

In the whole life cycle of infrastructure projects, and especially in their design phase, decision making activities within one owner are connected with the activities of another owner. These connections reflect the complex interdependencies among infrastructure owners that require the attention of actors in their network, who at the same time need the essential capabilities to collaborate. According to Keung et al (2013), these capabilities include components of relational skills, coordination, partner knowledge, and communication. The following studies present an overview of criteria to assess effective collaboration from different researchers. This analysis is focused on horizontal collaboration between infrastructure owners.

A relational management framework, developed by Keast and Hampton (2007), provides insights into relationship-based management strategies. The framework was based on network management literature and insights of a case study that involves the Australian Cooperative Research Centre for Construction Innovation. Their work identified four key relational management criteria: activating, framing, mobilizing, and synthesizing. The first, activating refers to the need of finding the right members of the network and accessing their skills, knowledge and resources. The second aspect, framing involves shifting orientation from single to collective roles and involves establishing and influencing the rules, values, and norms of the network to achieve more collectively. The third aspect, mobilizing consists of the different ways of working together between actors to commit into a collective entity and avoid individual orientations. The final aspect, synthesizing refers to building and maintaining the relationship within the network, developing new rules for interaction, and cultural adjustments.

Keung & Shen (2013) presented a study with key criteria for measuring network performance within the construction industry, which include information exchange between project members, project communication system, knowledge sharing for collaboration, corporate culture for promoting networking, and learning capability in an intra- and inter-organizational setting. Particularly, with the criterion of effective knowledge sharing, Dyer & Nobeoka (2000), argue that it can be improved by motivating network teams to participate and share knowledge, preventing free riding, and transferring efficiently both explicit and tacit knowledge. Organizations can sustain their networking momentum and seek innovative ways of improvements by creating highly interconnected, strong tie networks and measuring their performance (Dyer & Nobeoka, 2000). The five parameters used for the analysis of inter-firm network operations consist of: relational skills, team coordination, trust-building, objective orientation and value creation. Focusing on these types of measuring parameters,

infrastructure owners have the opportunity to assess their levels of collaboration and improve their networking performance, especially in the design phase of projects.

Following the concept of collaborative relationships in projects, Suprapto (2016) created a Relational Capability Assessment tool (RECAP) for practitioners to measure the current state of relational aspects of collaboration in projects at different stages. The RECAP tool consists of four relational capability criteria and two performance criteria, mainly focused on a 'client-to-contractor' relationship. The relational capability criteria include: front-end definition, collaborative practices, relational attitudes, and teamworking quality. The performance criteria used are project performance and relationship continuity. This tool has been validated by project practitioners from the oil and gas industry from both the client and contractor perspectives. Suprapto (20016, pp v) argues that "project managers need to manage their relationship overtime at the permanent organizational level by improving shared relational attitudes, which are characterized by mutual trust, commitment, openness, and no-blame culture".

On a different view, Dietrich et al. (2010) developed a conceptual framework to explain the collaboration elements and their mutual dependencies in multi-partner projects. The authors derived their elements from literature and existing empirical studies on collaboration, knowledge sharing and project success. The framework identifies four different categories: (1) collaboration antecedents, (2) project collaboration quality, (3) knowledge integration capability, and (4) collaboration outcomes. They identified eight critical collaboration elements, which are roles and process for collaboration, trust between actors, physical and cultural proximity, alignment of incentives, commitment to projects, goal congruence and collaborative goals, conflict resolution, and expectation fulfilment. Moreover, the study shows a positive relation between project collaboration quality and knowledge integration capability that translates to three effective collaboration outcomes: project success, potential for learning and innovations, and future collaboration. It is important to point out that, even though these elements are defined by the author as critical factors for collaboration, they have also been analysed as criteria to evaluate cooperation in a research study by Ruijter (2019, p75).

Ruijter (2019) developed a theoretical framework from an interpretive approach, where trust and resilience (or adaptive capability) are essential criteria for collaborative relationships. Moreover, the conceptual model explains a balance between contract-based management and cooperation-based management in infrastructure projects and how this can be achieved through a process of narrative influencing of sensemaking and sensegiving. This narrative process "*allows team members to experience their own dilemmas and the effect of their actions and to encourage them to actively reflect on this individually and collectively*" (Ruijter, 2019 p.233). The study is focused on the relationship between the commissioning authority and contractor, in a hierarchical context. However, the study can be used to assess collaboration between infrastructure owners, because it uses network approaches and shows effective interpretations of events in infrastructure projects in The Netherlands that involve different asset owners. Similarly, Clegg et al (2017) emphasize the importance of the process of sense-making in projects, because there are many assumptions of engineering and hard systems thinking that do not transfer to all stakeholders of a project, where different relational politics and powers play important roles.

Table 1: Criteria to assess inter-organizational collaboration

Author (s)	Form of collaboration	Research Method and Model	Identified Criteria set
Keast and Hampton (2007)	Relationship Management Framework	Case study with 11 semi-structured interviews to key network members of the Cooperative Research Centre for Innovation (CRC CI)	• Activating: Forming memberships and accessing resources • Framing: Shifting orientation from single to collective • Mobilizing: Securing commitment to whole or collective identity • Synthesizing: Building and maintaining relationships
Dietrich et al. (2010)	Collaboration, Knowledge integration, and project success	Literature study approach from empirical studies and theoretical literature	• roles and process for collaboration • trust between actors • physical and cultural proximity • alignment of incentives • commitment to projects • goal congruence and collaborative goals • conflict resolution • expectation fulfilment
Keung & Shen, (2013)	Networking Performance	Questionnaire Survey with 119 responses. With Performance measures of inter-firm network operation	• Information exchange • Communication system • Knowledge sharing for collaboration • Corporate culture for promoting networking • Learning capability
Suprapto, M. (2016)	Inter-organizational relationships	Multiple case study of 3 projects and 6 project practitioners with Relational Capability tool (RECAP)	• Relational capability criteria: • Front-end definition • Collaborative practices • Relational attitudes • Team-working quality • Performance criteria: • Project performance • Relationship continuity
Ruijter, H (2019)	Resilient Partnership	An interpretive approach to public-private cooperation in large infrastructure projects	• Trust &Resilience • Control-management vs. Relationship-management

The aforementioned criteria describe elements and dimensions necessary for effective inter-organizational collaboration, listed in Table 1. They capture the core capacities and competencies for successful collaboration in projects. Since most researchers use these elements interchangeably, they will be categorized into three different collaborative capacity categories (individual, relational and organizational) to organize more appropriately the

criteria and to select the best criteria for the specific context of horizontal collaboration between infrastructure owners. It is important to point out that even though some of these elements were examined as success factors by their authors, it is argued that they can potentially be considered as criteria for evaluating collaboration (Shokri-Ghasabeh et al., 2009), depending on their definitions and argumentation. To clarify this point, factors are considered actions to execute in order to have successful collaboration whereas criteria are elements to assess or measure successful collaboration. For example, Shokri-Gasabeh et al (2009) argues that the element of 'time' or 'schedule' is considered as an important and fairly common criteria to measure the success of project delivery. However, 'time' can also be identified as a successful factor if it is considered as a manageable component by the evaluator.

The concept of collaborative capacity is identified to be essential when considering the whole lifecycle of an infrastructure project and to achieve project success (Shelbourn et al., 2007). In the following sections of this chapter, the identified criteria have been categorized into three collaborative capacity levels: individual capacity, relational capacity, and organizational capacity. The proposed categorization is adapted from the result of intensive literature review on the subject of building collaborative capacity in community coalitions, developed by Foster-Fisherman et al (2001), and the criteria is further refined to be applicable in the specific context of horizontal collaboration.

3.3 Collaborative Capacity Assessment Framework

3.3.1 Criteria for Horizontal Collaboration

According to Emuze & Smallwood (2014, pg. 294), collaborative capacity in the construction industry refers to the ability of organizations to agree upon mutual goals, decision-making processes and troubleshooting systems in a specific project. Infrastructure asset managers need to improve their collaborative capacity in their networks in order to upgrade and maintain efficiently the functionalities and quality of their infrastructures in order to achieve added value to their networks (Hertogh et al., 2018). It is argued that the process of building collaborative capacity can be time consuming and requires strong leadership, the development of a shared vision, the willingness to recognize differences and ensure equality between partners (Cropper, Ebers, Huxham, & Ring, 2008). Foster-Fisherman et al. (2001, pg. 242), define collaborative capacity as "the conditions needed for coalition (networks) to promote effective collaboration and build sustainable community change". The following Table 2 presents the proposed criteria by this study for horizontal collaboration, which are divided into three main categories: within the members (individual capacity), their relationships (relational capacity) and within their organizational structure (organizational capacity). Based upon a theoretical review executed by Foster-Fishman et al. (2001) that developed an integrative framework for building collaborative capacity in community coalitions, an assessment framework is proposed to assess horizontal collaboration between infrastructure owners. The framework is built by comparing and relating the criteria identified in the literature review previously analyzed (see Table 2).

Table 2: Criteria for collaboration assessment

Category	Criteria	Sub-criteria and indicators from literature
(i) Individual Capacity	i.1) ability to work with others	• Member's effective communication, knowledge about norms
	i.2) ability to create and build programs	• Understand targeted problems or interventions, knowledge in policy and community
	i.3) positive attitudes and motivations	• Committed to collaboration, collaborative believes (vision, goals, production)
	i.4) positive attitudes about stakeholders	• Respect different views, trust other stakeholders
	i.5) positive attitudes about self	• Select relevant and capable members, innate expertise and knowledge bases.
(r)Relational Capacity	r.1) Knowledge sharing	• motivate knowledge distribution and participation • Multi-lateral relationships • Transfer explicit and tacit knowledge.
	r.2) Positive working climate	• Cohesive, cooperative, trust, open and honest
	r.3) Shared vision	• Joint working process. • Common understanding of problems and shared solutions • Establish common vision and mission
	r.4) Power sharing	• Participatory decision-making process • Supporting network champions
	r.5) Value diversity	• Group differences appreciated • Multiple perspectives
	r.6) Relationship continuity (internal and external)	• Build and maintain relationships • Links with policymakers and community leaders
(o)Organizational Capacity	o.1) Effective leadership	• Excellent administrator/senior management, visionary and committed to support collaboration • Driving the relation to achieve outcomes
	o.2) Formalized procedures	• Team coordination and integration • Processes of collaboration (rules, values, and norms in the network.)
	o.3) Effective communication	• Internal and external communication • Build communication processes • Problem discussion and resolution
	o.4) Sufficient resources	• Resource organization (physical, material, equipment) • Financial and personnel resources to implement and operate the process
	o.5) Improvement orientation	• Develop monitoring systems and adapt to evaluation criteria • Responds to change and feedback
	o.6) Innovation	• Provides innovative services and solutions

		• Introduce and champion new ideas of data sharing

Source: Developed by the author based on Foster-Fishman et al. (2001).

After a systematic review and in-depth content analysis of the 6 empirical studies, from section 3.2 of Chapter 3, a detailed comparison was made with the 17 criteria definitions and indicators, which are compiled in Table 3. Using the qualitative data analysis software Atlas.ti, each criterion was coded into the software and then analyzed in detail for similar or related meaning from the empirical studies. For example, Keast & Hampton (2007), as well as Keung & Shen (2013) studies include knowledge sharing as important criterion in their theoretical frameworks for collaboration. Keast & Hampton (2007) identify in their synthesizing phase, the development of a communication system able to facilitate high levels of information sharing. As of Keung & Shen (2013), component 3 of their framework, consists of an explicit component that relates to the performance of knowledge sharing. The following sections describe in detail all the commonalities, differences and correlations of each criterion within their established categories of individual capacity, relational capacity and organizational capacity.

Table 3: Collaborative Capability Criteria compared with empirical studies

Category	Criteria	Sub-criteria	Definitions and indicators from literature				
		from Foster-Fisher et al (2001)	Keast & Hampton (2007)	Dietrich et al (2010)	Keung et al (2013)	Suprapto (2016)	Ruijter (2019)
(i) Individual Capacity	Ability to work with others	Conflict resolution, effective communication	✓	✓			
	Ability to create and build programs	Understand targeted problems or interventions, knowledge in policy and community	✓	✓		✓	✓
	Positive attitudes and motivations	Committed to collaboration, collaborative believes					✓
	positive attitudes about stakeholders	respect different views, trust other stakeholders	✓				
	positive attitudes about self	Select relevant and capable members, innate expertise and knowledge bases.	✓				
(r)Relational Capacity	Knowledge sharing	motivate knowledge distribution	✓		✓		
		Multi-lateral relationships	✓		✓		
		Transfer explicit and tacit knowledge.	✓		✓		
	Positive working climate	Cohesive and cooperative, mutual trust	✓	✓	✓	✓	✓
		Open and Honest	✓	✓		✓	
	Shared vision	Joint working process	✓	✓		✓	
		Common understanding of problems and shared solutions	✓	✓		✓	
	Shared Power	Participatory decision-making process	✓			✓	
		Supporting network champions	✓			✓	
	Value diversity	Group differences appreciated	✓		✓		✓
		Multiple perspectives	✓				✓
	Relationship continuity	Build and maintain relationships	✓	✓		✓	
		Links with policy makers and leaders	✓	✓		✓	
(o)Organizational Capacity	Effective leadership	Excellent senior management	✓			✓	✓
		Driving the relation to achieve outcomes	✓			✓	✓
	Effective communication	Internal and external communication	✓	✓	✓	✓	✓
		Build communication processes	✓	✓	✓	✓	✓
		Problem discussion and resolution		✓	✓	✓	✓
	Formalized procedures	Team coordination and integration	✓	✓	✓	✓	
		Processes of collaboration (rules, values)	✓	✓	✓	✓	
		Charters / Contracts		✓			
	Sufficient resources	Resource organization (physical, material)	✓	✓			
		Financial and personnel resources	✓	✓			
	Improvement orientation	Develop monitoring systems	✓	✓	✓		✓
		Responds to change and feedback		✓	✓		✓
	Innovation	Provides innovative services and solutions	✓				
		Introduce new ideas of data sharing	✓				

3.3.2 (A) Individual Collaborative Capacity

As projects become more complex and interconnected, having the right individuals in a project team is becoming more crucial to organizations, and perhaps people are their most important assets. According to Bakker (2018), one of the most important and most difficult requirements to make a positive difference to the performance of projects is to build a truly integrated team. In order to achieve an integrated team, individuals need to develop the right set of skills and managerial capabilities, which are also considered as preconditions for successful collaboration. More specifically, individuals need to know how to cooperate, resolve conflicts, communicate, be committed to collaboration, and tolerate diversity and different views (Foster-Fishman et al., 2001). Within this line of vision, Suprapto (2016) identified a criterion of front-end definition as the ability to comprehend the project scope, the basic design, execution plan, roles and responsibilities of members, and if these are understood by individuals of the project team. Also, Keast & Hampton (2007), refer to the need to identify and select relevant network members in their Activating criteria to bring to the project the right resources, skills and knowledge to improve decision making. Dietrich et al. (2010) emphasizes the important of individual roles in the process of collaboration to achieve effective knowledge collaboration and application. Moreover, Ruijter (2019) refers to the importance of individual perceptions to understand problems and the context to which they take place are decisive for intervention and improvement. Also, he states that to have a resilient partnership requires a significant change in attitude by the public authority and other actors. Therefore, the criteria selected for this study are: the ability to work with others, ability to create and build programs, having positive attitude and motivations, having positive attitude about stakeholders and about themselves. It is important to note here that, while establishing and evaluating the necessary individual capacity as preconditions for IOC, this study is mainly focused at assessing their individual contribution based on the team organization as a whole, rather than their single individual capacity to collaborate.

3.3.3 (B) Relational Collaborative Capacity

Positive inter-organizational relationships promise to decrease uncertainty levels and produce trust between organizations, which ultimately generates unique information on the capabilities and reliability of the networks (Cropper et al., 2008). Positive relational capabilities provide access to needed resources, promote stakeholders commitment, satisfaction, and involvement required for successful collaborative endeavors (Foster-Fishman et al., 2001). The criteria identified in this category are: knowledge sharing, positive working climate, shared vision, power sharing, value diversity, and relationship continuity. Table 5 provides a comparison list of these criteria with the descriptions and definitions from different criteria sets, identified in the empirical studies. For instance, for knowledge sharing, Keung & Shen (2013) provide six measures related to knowledge sharing for collaboration, while Keast & Hampton (2007) identified that information sharing can be facilitated by developing a communication system in what they call a ‘synthesizing phase’. For positive working climate, Dietrich et al (2010) identified in project collaboration quality, the element of mutual support, which is the willingness of actors to help each other in achieving common goals. While Suprapto (2016) identified team working quality, that reflects the actual interactional activities between team members based on synergies.

Table 4: (R) Relational Collaborative Capacity criteria, definitions and indicators

Identified Criteria	Definitions of Indicators from literature	Author (s)
r.1) Knowledge sharing	Knowledge sharing for collaboration: multi-lateral relationships, and transfer both explicit and tacit knowledge.	Keung & Shen, (2013)
	Synthesizing phase creates the environment for (3) developing a communication system able to facilitate high levels of communication and information sharing.	Keast & Hampton (2007)
	A flexible organization structure encourage knowledge sharing and collaboration across boundaries.	Dietrich el al (2010)
r.2) Positive working climate	Framing: Stressing the benefit of working together	Hampton (2007)
	Mutual support: Willingness of collaborating actors to help each other in achieving commonly agreed-upon goals. H2: Trust between actors. H5: Commitment to project. Cohesion: Existence of the collaborative spirit between actors.	Dietrich el al (2010)
	Team working quality: reflects the actual interactional activities between team members based on synergies. Indicators such as cohesion, cooperation, mutual trust, open and honest.	Suprapto, M. (2016)
	Mutual support: the degree to which two teams support each other to solve problems that emerged in their interdependent tasks.	Suprapto, M. (2016)
	The development of resilience and trust between partners are given shape by means of a social interaction between individuals.	Ruijter, H (2019)
r.3) Shared vision	Building a collective identity with common missions and vision.	Keast and Hampton, (2007)
	Aligned efforts: Alignment of contributions provided by collaborating actors. The correspondence between actors' priorities in collaboration and commonly agreed.	Dietrich el al (2010)
	Aligned effort: The extent to which the teams align their effort. Best effort to the project. Shared objectives	Suprapto, M. (2016)
r.4) Power sharing	Mobilizing: Securing commitment on scale and scope of action. Encouraging shared power and decision-making process. Identify and foster network champions (natural leaders).	Keast and Hampton, (2007)
r.5) Value diversity	Framing: understanding and examining the perspective of other members	Keast and Hampton, (2007)
	It is important for the parties to be able to transcend their own interests to benefit the joint interest that focuses on achieving the joint project results.	Ruijter, H (2019)
r.6) Relationship continuity	It is important to continue the relationship in the future between networks for good project performance. Long-term relationships may lead to successful projects	Suprapto, M. (2016)

	Synthesizing: Building and maintaining relationships	Keast and Hampton, (2007)

The need for trust is recognized in many categories, and it has always been an issue between commissioning authorities and other organizations. However, it is important to point out that trust may be overemphasized, and in many cases the reason for some confusions. Collaboration between clients can function as arenas in which distrust can be managed. A shared vision may be highly desirable but equally it may be possible for different organizations to have different objectives and visions and still obtain the desired outcomes from working together. Moreover, trust may lead to inefficiencies, creating for example more unnecessary processes to produce trust among actors than necessary for purely common transactions (Zucker, 1985).

3.3.4 (O) Organizational Collaborative Capacity

Organizational capacity is critical to the effective implementation of laws, policies and programs (Bryan, 2011; Foster-Fishman et al., 2001; Ting, 2011), and has been broadly defined as "the ability of an organization to fulfil its goals" (Bryan, 2011). Similarly, Foster-Fishman et al (2001) refers to organizational capacity as "the ability to organize members in a productive way in order to engage them in required work tasks to produce a desired product". The sub-criteria selected to describe this category are effective leadership, formalized procedures, effective communication, sufficient resources, continuous improvement orientation, and promote innovation. The definitions and indicators identified from the literature review are listed in Table 6.

Table 5: (O) Organizational Collaborative Capacity criteria, definitions and indicators

Identified Sub-criteria	Definitions of Indicators from literature	Author (s)
o.1) Effective leadership	Senior management is visionary and committed to support collaboration Leadership with organizations and communication	Suprapto, M. (2016)
	Driving the relationship to achieve outcomes	Keast and Hampton, (2007)
o.2) Effective communication	Sufficient, open and efficient information exchange Internal and external communication	Dietrich el al (2010)
	Build communication processes Establishing processes to enable members to work through conflict	Keast and Hampton, (2007)
o.3) Formalized procedures	Establishing and influencing operating rule, values, and norms in the network.	Keast and Hampton, (2007)
	Organizing regular meetings among members Delivering ways of collaborating with members	Keung & Shen, (2013)

	Conducting coordination activities connecting members Connecting different individual relationships into a network	
o.4) Sufficient resources	Resources of organizations (personnel, physical, materials, equipment)	Kożuch & Sienkiewicz-Małyjurek (2016)
o.5) Improvement orientation	Continues monitoring to ensure that the needs and resources of members continue to be directed towards a common strategic purpose	Keast and Hampton, (2007)
o.6) Innovation	Synthesizing: Establish network and innovation culture Framing: Introduce and encourage new ideas	Keast and Hampton, (2007)

4. Case Study

4.1 Research Strategy

Since there is a lack of empirical analysis in the field of inter-organizational collaboration with a horizontal perspective, the methodology employed for this research project falls under the exploratory approach with case study (Gerring, 2004). Moreover, Yin (2009) argues that a case study is suitable for 'how' and 'why' type of research questions, which are more explanatory and likely to lead to the use of case studies. Thus, since the nature of this study focuses on a 'how' type research question, this study selects two exploratory case studies. A case study is defined by Gerring (2004) as an intensive study of a single unit for the purpose of generalizing and understanding a large sample of similar units. The selection strategy of the case studies has the objective to obtain a representative sample of the Dutch infrastructure industry and to have useful variations on the selected collaborative theoretical criteria in order to make an analytical generalization.

The Zandhazenbrug and The Meanderende Maas projects serve as two positive cases of collaboration within the Dutch infrastructure industry, which arguably reveal similar patterns of interdependencies and collaboration, despite their many differences in type of infrastructure, complexity, number of clients, and duration. These are dimensions that have been conventionally associated with differences in infrastructure project development (Hertogh & Westerveld, 2010; Bosch-Rekveldt et al., 2011). In terms of the project background, the Zandhazenbrug and the Meanderende Maas projects also differ with respect to the planning, design and complexity type. The Zandhazenbrug is a railway bridge replacement, which was successfully finished in 2016 and involved the collaboration of two important infrastructure operators of the Dutch infrastructure industry, Rijkswaterstaat and ProRail. The project was characterized with high technical complexity (Ruijter, 2019; Bosch-Rekveldt et al., 2011). The Meanderende Maas is an integrated project of a combination of dyke reinforcement, river widening, spatial quality and area development, located along the river Meuse between Ravenstein and Lith, which is currently in the detail design process and it´s planned to be completed by 2028. It involves a coalition of ten stakeholders and asset managers of the Dutch infrastructure industry. This project is arguably characterized with high organizational and environmental complexity (van den Brand, 2020; Bosch-Rekveldt et al., 2011). Yet, strong similarities can be observed in the trajectories of developing effective collaboration. Both projects were selected because of their changing environment and complex interdependencies between important asset managers of the Dutch infrastructure industry.

4.2 Qualitative Analysis

Interviews with key informant stakeholders were conducted during the months of March, April and May 2020. An initial planned sample was preliminary established based on document review as well as on connections and suggestions made by TU Delft professors and PhD researcher. Interviewees were selected for their involvement, knowledge and experience in project teams within each organization; they included project managers, stakeholder

managers, contract managers, policy advisors, and manager coordinators that were involved in key moments of the design phase of the projects. The interviewees have a range from 5 to 20 years of experience in managing projects. As interviews developed, the size of the sample increased through referrals using the technique of snowball sampling. Interviews were conducted in English, and according to the established protocol shared prior to the interview with the key informant respondents. Interviewees were asked whether they felt comfortable with being recorded. The interviews were open-ended, semi-structured, and on an individual basis to allow for in-depth exchanges of contextual knowledge, viewpoints and experience of the interviewees regarding IOC within the project framework. Table 6 is a list of the interviewees and the organizations they represent and the position they represent.

Table 6: Key-informant Interviews background

Key-Informant Interviews		
Project # 1: Zandhazenbrug		
Interviewees	Organization	Position
Interviewee 1	ARUP	Senior Consultant
Interviewee 2	Rijkswaterstaat	Contract manager
Interviewee 3	Rijkswaterstaat	Portfolio Manager
Interviewee 4	Prorail	Project Manager
Project # 2: Meanderende Maas		
Interviewees	Organization	Position
Interviewee 5	Waterschap Aa en Maas	Stakeholder Manager
Interviewee 6	INFRAM	Project Manager
Interviewee 7	Waterschap Aa en Maas	Policy Advisor
Interviewee 8	Ministry of Infrastructure and Water Management	Directorate for Water Safety, Climate Adaptation and Governance
Interviewee 9	Natuurmonumenten	Project Coordinator

As previously mentioned, a protocol was sent to all interviewees at least 2 to 3 days before the interview for their guidance and information about the research project (see Appendix A). In addition, a predetermined IOC Criteria matrix (see Appendix B), selected from the literature review, was sent to respondents in a separate e-mail for their rating by assigning a score of 1: Most Disagree, 2: Disagree, 3: Agree, 4: Most agree (see Appendix B). These IOC Criteria were sent to the respondents after the interviews were conducted, in order to maintain the interview free of biased views from respondents due to the information shared in the IOC Criteria. Finally, all interviews have been transcribed from their audio-recordings before entering them into Atlas.ti for thematic analysis and extracting results.

4.3 Document review

To triangulate the source information obtained through the interviews, a document review has been carried out in the project. The first step consisted of reviewing the organization documents that are accessible online. The documents analyzed included policy and ministerial agreements, project agreements, workshop documents, reports, and media documents regarding the project and the theme of collaboration. Second, interviewees were asked for internal documents not available online, such as informal agreements, meeting presentations, and internal workshop reports that can be considered important for the research. The aim of the document review was to analyze the evolution of each organization

and their position regarding IOC. All documentation obtained has been translated from Dutch to English and entered into Atlas.ti for thematic analysis and extracting results, as well.

4.4 The Case Studies – learning from theory to practice

This section covers a brief description of the projects, along with the background of the organizations (owners) involved in each project, their involvement and experience with IOC and what the respondents recognized as criteria to assess levels of horizontal collaboration in the specified categories: individual, relational and organizational capacity. The insights are drawn from the document review, key informant interviews with high and mid-raking managers and advisers, and the criteria evaluation matrix filled in by the participants.

4.4.1 Case Study #1: The Zandhazenbrug – Learning from the experts

The new railway bridge located at the A1/A6 Muiderberg junction, also known as The Zandhazenbrug refers to the nickname of the residents of that region (Rijkswaterstaat, 2018). The bridge forms part of a large-scale reconstruction and upgrading program of the road network between Schiphol-Amsterdam-Almere (SSA A1/A6/A9 and A10-east roadways), which is the largest infrastructure program in The Netherlands from the start of its realization date in 2012 (MIRT, 2016). The program has been contracted through different Design, Build, Finance & Maintain (DBFM) contracts (Ruijter, 2019), with an estimated cost of over 5.06 billion euros including contributions from third parties for the amount of €162 million (MIRT 2016).

Figure 3: The Zanhazenbrug, Muiderberg (source:Rijkswaterstaat, 20108)

The iconic railway bridge (see Figure 3), spanning 255 meters over the 16 lanes A1 motorway without any intermediate support, is considered the largest railway arch bridge in Europe (IVormatie, 2017), and was awarded the National Steel Prize in 2018 (Rijkwaterstaat, 2018).

The railway bridge combines a concrete reinforcing base with a 55-meter-high steel arch constructed with high strength steel grade S460 that weights a total of 8.5 million kilograms (IVormatie, 2017).

The commissioning authority (client) normally responsible for the planning and execution of this railway project would have been ProRail. According to Section 16a of the Railways Act of the management concession (2017), ProRail is in charge of the management of the Netherlands railway network. This client works as a private company under the Dutch law, whose only shareholder is the State of the Netherlands (ProRail, 2017, pp.1-3). However, the Zandhazenbrug project was agreed to be directly commissioned by Rijkswaterstaat (Ruijter, 2019). Rijkswaterstaat, the Directorate General for Public Works and Water Management, is an executive agency of the Dutch Ministry of Infrastructure and Water Management in the Netherlands. The agency is responsible for the design, construction and management of motorways and waterways of the Netherlands (Rijkswaterstaat, 2020). A cooperation agreement was made between Rijkswaterstaat and ProRail to join forces and have only Rijkswaterstaat as whole responsible of the project, not only because the motivation for the Zandhazenbrug was the widening of the A1 motorway, but also due to the high risk profile and complex interfaces between the motorway and railway systems (Ruijter, 2019). The successful completion and hand-over to its owner and operator (ProRail) took place in August 2016 (Rijkswaterstaat, 2016).

Ruijter (2019) states that the railway bridge was one of the most complex and riskiest components of the entire SAA program, and therefore, it needed to be treated with a different approach than the usual way in which Rijkswaterstaat and ProRail would treat projects with interconnections in the past. Indeed, according to a Rijkswaterstaat's official, a project with interfaces would normally be separated in two different projects, one with ProRail in charge of the railway expansion and another with Rijkswaterstaat in charge of the road networks and waterways. A similar narrative was given by a ProRail official, who stated that they are not used to work with Rijkswaterstaat, and that most of the time they do all of the work themselves. However, for this project both clients decided for an integrated approach and create a collaboration agreement, that according to a Rijkswaterstaat official it was called *"Samenwerkingsovereenkomst (SOK)"* in Dutch. He further explained that the agreement was made not only to specify the roles of each organization, in terms of accountability and financial responsibility, but also to deal with the high-risk profile of the project and to have constant communication with each other.

In addition, the collaboration agreement included a dedicated Project Manager from ProRail to be incorporated into the Rijkswaterstaat's Integral Project Manager (IPM) Team, while Rijkswaterstaat would bear the final responsibility for the entire project (Ruijter, 2019). This was confirmed by representatives of both organizations, who stated that this decision was made because the project had many complex interfaces, and therefore, they needed constant dialogue between both organizations, especially with critical issues during construction activities, such as traffic closures of the roadway or railway (Ruijter, 2019). The IPM model (see Figure 4) has been implemented by Rijkswaterstaat since 2006 to ensure that all internal and external cooperation runs as smoothly as possible (Integraal projectmanagement, 2019). The IPM model has been successful not only to ensure that project management was recognized as a real profession within Rijkswaterstaat, but also to bring uniformity in project

management and guarantee a structured organization of the risk management process throughout the project by different disciplines and roles (Wermer, 2018). There are five main roles in the Rijkswaterstaat IPM team: the Project Manager is at the top level and is responsible for the project as a whole and ensures coordination, followed by the Planning & Control Manager, and below is the Stakeholder Manager, Contract Manager, and Technical Manager. Normally, the Stakeholder Manager is responsible for the collaboration activities with other clients and public organizations (Wermer, 2018). As one Rijkswaterstaat official explained, the Project Manager from ProRail formed part of the Technical Manager team, who followed railway works very closely, and was present at most of the meetings. In his words: "*this person became a team member of the Rijkswaterstaat's IPM team and was actively involved in all the decisions of the team to keep the information flowing*". However, the interviewee continued that Rijkswaterstaat is not used to have a member from a different organization in the IPM team. Nonetheless, he recommends to make this form of collaboration a usual practice in complex projects because, according to his comments, this improves information sharing between organizations. Furthermore, he explained that it is wise to keep all actors very close to keep the information flowing, and therefore, to improve collaboration between clients. Still, he recognizes that it is not easy to organize these sort of arrangements due to organizational and political sensitivities.

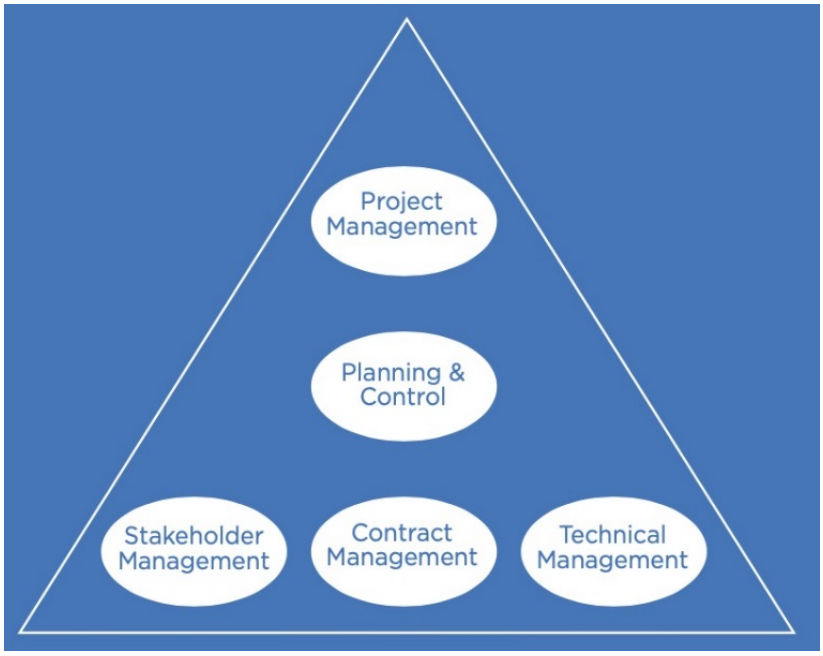

Figure 4: RWS Integral Project Management (IPM) Model (source: Ruijter, 2019)

According to a ProRail representative, his organization does not follow the same IPM model, however, they are currently discussing to implement part of this model in their way of working. This is because they can see the advantages in having the system, as it is very clear who is responsible for every task, which at the moment is not so clear in ProRail. The representative further explained that they want to implement some roles from the IPM model, such as, for example, the technical manager and contract manager, but this is now in an experimental phase. He also explained that the biggest difference between the two companies is that ProRail has about 1000+ small projects and just about 100+ large projects, which does not justify so many managers on one small project, as opposed to Rijkswaterstaat that mainly has large infrastructure projects.

While an important aspect of the IPM model is the constant discussion spaces among the five managers within the team (Wermer, 2018), this could be compromised if people involved in the team do not possess the right skills to collaborate. Individuals from project teams need to be able to communicate, to resolve conflicts, and cooperate with others in order to have successful collaboration. Representatives from both organizations saw the ability to communicate thoughts and how to relate to other counterparts as preconditions for good collaboration. They stated that if people work together well, with a positive attitude, they can solve any issue with the right competences. However, one official from ProRail explained that some people are not "natural collaborators", and therefore, they might not be able to perform well on the team. He insisted that a good match between team members to work together and commit to each other was fundamental for the good performance and collaboration within the team. A similar argument was given by a representative of Rijkswaterstaat, who stated that the most important criterion for him is to have the right people, with the right experience in working with complex projects. However, he acknowledges that as easy as it sounds, it is very difficult to find the right people for the project.

As much as it is important to have the right people for the project, a good relational connection between organizations emerged as a theme time and time again. It came up in terms of multilateral relationships, build and maintain relationships, and participatory decision-making process. As one interviewee explained, it is important to have the right connections on several levels between organizations as couples. According to the official, having a partner in the other organization as a counterpart of the project to deal with issues and have connections on every level of the project improves collaboration between clients. In his words: "*you need to find connections like a zipper on the project in order to connect the organizations*". If the connection is only made with one person of a team, for instance, only the technical manager, and the rest of the team has no other connections, then in his opinion, collaboration becomes more difficult. He added that the ideal connection needs to be at all levels of the organizations, from the top management, to the advisors and even specialists. However, he recognizes that having a counterpart couple on lower levels is hard to achieve because some specialists are afraid to be blamed if something goes wrong, in terms of time or money. Therefore sometimes they prefer not to collaborate with their counterparts. However, the official argues that if their senior manager gives them support and confidence to make the right decision as specialists, so they can have the freedom to make decisions, collaboration will be better between counterparts. If there are problems along the process and the specialist thinks that there could be some consequences, they should be able to share these issues with their leader. According to the official, their leader will have to deal with the consequences, but after all, that is his/her responsibility.

The ability to value diversity was a pervasive topic. Representatives from both organizations agreed that understanding the corporate culture of each organization is a very important component for successful collaboration. One official stated that, since the two organizations are very different, have different goals, members need to recognize and be aware of these differences to anticipate any type of dilemma that might appear over time. What is more, another official explained that Rijkswaterstaat sometimes manages project discussions in a more informal manner, and then they turn these discussions into formal agreements once a

decision is reached, whereas ProRail acts in a more formal manner thoroughly from the onset of discussions until the end of the solution. Therefore, he explained, people need to know these cultural differences in order to have effective communication between organizations.

Various responses to the open-ended question on do you think collaboration was successful suggest that participants felt that collaboration between Rijkswaterstaat and ProRail was indeed successful in this project. No one reported that they felt that there was no collaboration. Despite the difficulties and complex challenges of the project, participants across the organizations maintained that both commissioning authorities used different measures to ensure collaboration between each other.

4.4.2 Case Study #2: The Meanderende Maas – Learning from a coalition of collaborators

The Meanderende Maas project consists of an integrated approach of dyke reinforcing, river widening, improving spatial quality and developing new areas through a collaborative coalition of ten main stakeholders (van den Brand, 2020). Located between Ravenstein and Lith, the project is part of the Flood Protection Program, called *"Hoogwaterbeschermings-programma (HWBP)" in Dutch*, which its driving force is to meet the new flood safety standards applicable since 2017 (MIRT, 2016). The project is also part of the Delta Programme Strategy, which covers the protection of the whole Meuse river with dyke protection and room for the river (Meanderende Maas, 2019). The scope of work covers over 26 km of dyke reinforcement, riverside channels, lowered river banks, reactivation of natural old meanders including recreational areas and area development, improve port access of Oss, new riparian woodlands, new bike and walk trails (De Meanderende Maas, 2020). According to the Multi-year program Infrastructure, Space and Transport of 2016, the initial estimated costs for this project are €126 million euros, with a range from €63 to €189 million. The financial contribution comes from the HWBP funds, the MIRT funds, The European Water Framework Directive (WFD) and contributions from the ten main stakeholders of the region (MIRT, 2016).

Figure 5: The Meanderende Maas Project (Source: De Meanderende Maas, 2020)

As stated before, the Meanderende Maas relies on the close collaboration of ten different asset owners and stakeholders, working together as a coalition: [1] The Water Board of Aa en Maas, who is the leading organization, [2] Water Board of Rivierenland, [3] The province of Noord-Brabant and [4] the province of Gelderland, [5] Municipality of Oss, [6] Municipality of West Maas, [7] and the Municipality of Waal and Wijchen, [8] Natuurmonumenten, [9] The Ministry of Infrastructure and Water Management, and [10] Rijkswaterstaat (De

Meanderende Maas, 2020). All organizations are considered as important owners of the project, not only because they influence the project on different levels, such as spatial planning and land acquisition, but also because they all contribute financially with the design and realization phases of the project.

With the initiative of the leading organization, the Water Board of Aa en Maas, and in order to better deal with the organizational and technical complexity of the project, the coalition of stakeholders started with a shared strategic vision of the project and decided to incorporate an external, private organization to take the role of Project Manager for the cross-boundary collaborative process. This external organization would be leading the initial exploration phase in order to investigate an optimum combination of measures of dyke reinforcement, room for the river, and area development (van den Brand, 2020). According to the Project Manager, they have incorporated an innovative integrated design approach with powerful interaction between all actors, which includes: the steering group from the coalition, a design team of experts, the inhabitants, entrepreneurs, and civil society organizations of the region. In addition, an overall sounding board advises the steering group and the Project Manager over the overarching interests of the agricultural sector, nature, business villages and cultural history (De Meanderende Maas, 2020). According to the interviewee, this was something very special about this process, as she explained that the fact that all clients have agreed to a joint-decision making process, with no exceptions, does not happen often. She further added that the preferred alternative was decided by all parties in a mutual agreement, while in most other cases, only one party has the final decision of the project outcome. According to van den Brand (2020), all actors have actively participated through several project workshops, dyke reinforcing table discussions, general information meetings and kitchen table discussions, to reach a consensus on a preferred alternative. In total, there were about 40 external stakeholders, with different interests and background, who participated in the workshops (De Meanderende Maas, 2020). The preferred alternative, signed by the steering group in December 2019, includes a combination of beneficial solutions in terms of flood safety, nature creation and cultural heritage, river measures that improve shipping routes and reduce the high water table, which allows for lower dykes, a more robust river system. The dyke reinforcing solution prevents property demolitions, improves spatial quality and incorporates new bike trails (van den Brand, 2020).

According to the Project Manager, their collaborative process is about building solutions together, and to do so, they used what they called a “design process” as a way of working. In this way, when they show the preferred solution on a map or a plan, with many graphical aids, people that are unfamiliar with the project can understand it and visualize better the solution. She explained that this is not only beneficial for other stakeholders, such as the inhabitants, but also for other authorities and interested parties. In addition, she added that when you show the design possibilities on a map, new opportunities can emerge. For instance, she explained that it was hard to integrate new bicycle routes on dykes because the financial constraints of dyke reinforcement does not allow to pay for them. However, by showing the design possibilities on a map, they found an alternative solution with local governments who could finance these new bicycle routes.

With regards to assessing the cross-boundary collaboration of the project, all interviewees unanimously agree that it was a successful collaboration process, which is reflected in the

final design of the preferred alternative. A representative of a Water Board believes that this has been achieved, among many reasons, due to a long tradition of collaboration in the region. In her words it is the "*brabantse cultuur van samenwerken"* in Dutch. According to her statement, the government calls them the "*koplopers*" in Dutch, which means the frontrunners of other regions in the Delta programs, and this has influenced the success of collaboration for this project. According to a representative of the leading Water Board, the incorporation of innovative design processes, especially aimed to promote processes of collaboration from the onset, has enabled a joint decision-making result. This gave the opportunity to all organizations to feel represented by the external Project Manager. However, it is important to note that some interviewees stated that the feeling of how much their organization was represented by this party was different from time to time. As a matter of fact, a high-level official from the Ministry of Infrastructure and Water Management, stated that those methods were new to some actors, and therefore, they did not give them much confidence with some of the design alternatives. She explained that this was mainly because, the coordinating party had all of the knowledge about the project, and the final results were carefully designed and shared as outcome oriented, with some visual aids but not showing hard data. This type of work was called "*werkend ontwerpen*" in Dutch, which means working by design. According to the respondent, sometimes this made some actors question the design and request for the hard data as the decisions felt to be outcome oriented. This was also confirmed by other representatives of the coalition, who were hesitating about the process at the beginning, and stated that they were not sure that the external Project Manager understood completely their main purpose on the project. As a result, there were some transparency and trust issues. Nonetheless, she stated that this issue would have probably happened anyway, if any other coordinator or stakeholder would have led the design process. Thus, according to her view, there will always be some trust issues in these types of projects. At the end, however, the hard data was available to all stakeholders and the final project worked out well and is solid, according to the interviewees.

On the other hand, in order to deal with trust and transparency issues, an official from the leading organization and the team of experts stated that is important to give access to all documentation through an online server, where clients and stakeholders can have access to the hard data, at any time. Also, additional dyke tables were arranged in order to facilitate interested clients and other interested stakeholders to review in detail the hard data of the designs. According to an interviewee, these were important elements to gain trust among team members. For instance, there were several group meetings, called 'Meanderende Maas Moment (MMM)*',* which gave the opportunity to clients to share their concerns and pose many questions about the proposed solutions. This has been verified and confirmed with meeting reports and formal agreements, provided by the respondents for analysis, called "*Bestuursovereenkomst*" in Dutch. The fact that there was an intensive participation of inhabitants and entrepreneurs of the region, shows that the preferred alternative includes the diverse needs of all stakeholders and the solution serves as a common strategic purpose. In addition, during this diverse set of workshops, a policy advisor of the leading organization stated that their intention was to be seen by all team members as one more client, possibly at the same level as others.

Another important criterion discussed by interviewees as relevant, in the category of relational capacity, is relationship continuity. According to an interviewee, having the same

person or the same organization involved over the years of the project is crucial to build and maintain relationships. He further stated that continuity of the relationship allows you to work and understand other organizational teams, where later you do not have to start from zero.

With regards to assessing collaboration on an organizational level, most interviewees consider it important to have an effective leader in the coalition. A representative of the leading organization, Aa en Maas, stated that charismatic leadership is essential for collaboration. In his own words: "*an effective leader should be able to keep a group together by handling them over a narrative and giving them the feeling that something special is happening that every member wants to be part of"*. In addition, it is important to mention how the Dutch government perceives these organizations on their documented agreement MIRT 2016 as "*koplopers*", which means leaders of the flood protection program (MIRT 2016, p9). On the same line, another key organizational criterion discussed with most interviewees was effective communication. In projects with multiple clients, such as the Meanderende Maas, effective communication becomes a challenge for successful collaboration. According to the Project Manager, it is important to know the project on several levels, examining the "why, what, and how" of the project. She explained that communication is effective if members can recognize the "why" level. She added that, since it is very hard to deal with many different regulations, requirements, and points of view, if team members have a joint point of view on the "why" of the project, then you can solve a lot of problems. She further explained that many regulations and procedures are on a "how" level, which can block the development process substantially. She concluded with an interesting analogy: *"I remember what the director of the leading Water Board used to say: we are playing a new game, but we still have the old rules, and sometimes we are really frustrated because the referee says that we are not allowed to do something. But we should not blame the referee, we should talk about the rules together".* With this quote, she illustrated that what the collaborative partners are trying to do is to re-invent ways of collaboration, but in the mean time they still have to play with the old rules and regulations, from which they need to assess their meaning in different forms and try to do their best with them, which is the starting point of the project organization.

Having formalized procedures is another important criterion that was mentioned often by respondents. This is evident at many different levels of the project organization. There are government policies, processes, formal and informal agreements that have been implemented throughout the exploration phase of the project. Starting with the MIRT/HWBP exploration system, at the national level, where it contains the state of affairs of all projects and programs of The Netherlands. In the MIRT system is where the Ministry of Infrastructure and Water Management allocates the funds for the exploration phases, and where all the commitments and agreements are stated with local governments responsible for the project's exploration and realization. Later, at project level the coalition has a formal agreement called "*Bestuursovereenkomst" in Dutch,* where all the joint-decision making objectives are stated in order to carry out the realization phase. To mention a few statements from the document: "The reinforcement of primary flood defense system (dyke section 36-3) in such a way that statutory safety standards of 1/10,000 years is achieved; Realization of at least 11 cm net water level reduction through river expansion measures; Achievement of Water Framework Directive (WFD) targets; Strengthening the spatial quality in the area and making it experienceable by, among other things, making it more accessible to the public".

The project also showed processes implemented that assess collaboration on an improvement orientation level, which seeks external expertise and adaptability. One process implemented, according to the external Project Manager, is “Gate Review”. Although this process is not new in the Dutch industry and neither within Rijkswaterstaat organization, Gate Review was treated as a new process by the coordination team of this project, according to the Project Manager. It involves a team of independent experts on dyke reinforcement, spatial design and project managers that from their own experience look at the selected alternatives to give their opinion and review the work. According to the Project Manager, the group of experts were very positive about the work and gave the project excellent recommendations, which is something that she feels very proud of and believed that it was a key aspect for the success of the preferred alternative as a consequence from effective collaboration.

Finally, innovation was the criterion least mentioned by respondents. What is more, an interviewee stated that innovation is nice to have, but not strictly necessary. However, it can be argued that this criterion falls in the vision of new collaborative methods previously mentioned, which was used by the external project management to steer the collaborative process. At the end, the solution was innovative and most interviewees unanimously agreed that it was successful, in terms of collaboration.

4.5 IOC Criteria Evaluation Matrix for Practitioners

As explained before, a predetermined IOC criteria Matrix selected from the literature was sent to participants to be filled out based on their experiences in the project. Participants read each criterion and chose the score that most accurately reflected the importance of such criterion to assess collaboration. The following results are based on the IOC Criteria framework selected from the literature review in Chapter 3 that was received from respondents with their ratings by assigning a score of 1: Most Disagree, 2: Disagree, 3: Agree, 4: Most agree. The calculation for the score for each criterion was carried out by dividing the total score assigned to the criterion from the assessment of individual practitioners by the maximum total points the criterion would have received if the criterion had been marked with the highest score.

4.5.1 Individual collaborative capacity

From the results of the assessment, the highest individual skills criterion is ‘positive attitude and motivations’ with a perfect score of 1 for the Zandhazenbrug and 0.88 for the Meanderende Maas. Followed by ‘positive attitude about stakeholders’, with scores 0.92, and 0.81, respectively. These results coincide with the most frequently responses mentioned by practitioners throughout the interviews, with ‘positive attitude and motivations’, which shows 9 occurrences. The second most frequent response by practitioners was ‘ability to work with others’ with 6 mentions, which also received a high score in the case of the Zanhazenbrug with 0.92 (see Appendix C). Most participants from both projects rated these set of criteria similarly, agreeing that holding a positive attitude and being committed to collaboration is very important to collaborate effectively between asset owners. The most noticeable

difference in the scores is from Client 4 of the Meanderende Maas project. The respondent gave a score of zero to criterion (i.5) (see Figure 6). This gave the lowest score to this criterion (0.56), and also was the least mentioned in the interviews (see Appendix C). Therefore, this study will not consider this criterion for the assessment tool as there are not enough evidence to support it.

Table 7: Individual capacity

(I). Individual capacity			
#	Criteria	ZandhazenB	Meanderende
i.1	ability to work with others	0,92	0,75
i.2	ability create and build programs	0,83	0,75
i.3	positive attitudes and motivations	1,00	0,88
i.4	positive attitudes about stakeholders	0,92	0,81
i.5	positive attitudes about self	0,83	0,56

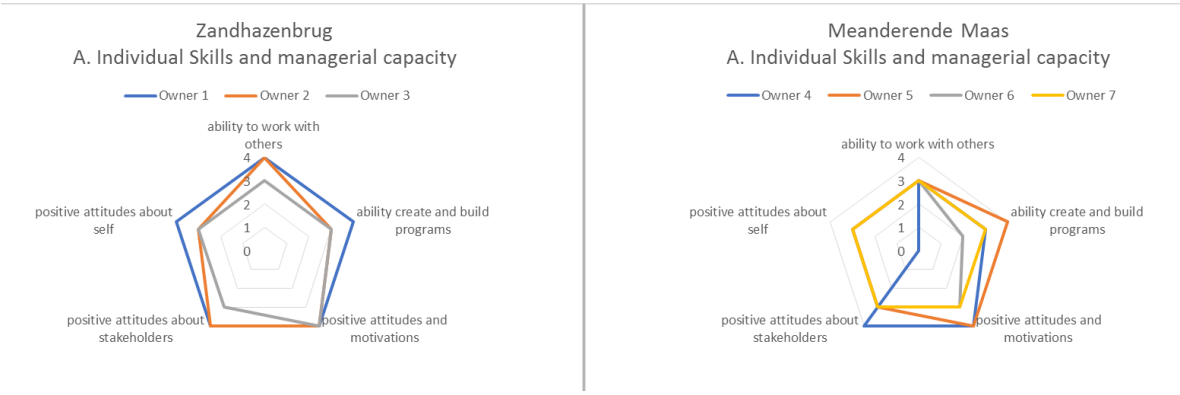

Figure 6: Individual collaborative capacity - Rating Scores from each respondent

4.5.2 Relational Collaborative Capacity

The results of the assessment show that practitioners from both projects find 'positive working climate' as the most relevant criterion with a perfect score of 1 for the Zandhazenbrug project and 0.94 for the Meanderende Maas, followed by 'shared vision' with 0.88 in the case of the Meanderende Maas project and 'relationship continuity' with 0.92 for the Zandhazenbrug .In contrast, the most frequent criterion mentioned in the interviews was shared vision, with 16 occurrences, followed by 'positive working climate' and 'knowledge sharing' with 11 and 8 counts respectively (see Appendix C). Evidently, the overall scores show that practitioners consider that having a positive working climate through cooperation, cohesion and with mutual trust between owners is very important for effective horizontal collaboration. Most criteria are rated with high scores, with exception of scores from Client 6 with low scores to relationship continuity and power sharing in the Meanderende Maas project. The difference of scores between client 6 and the other partners show that participatory decision making and the intention to continue the relationship between organizations seems not as important for this asset owner as for the rest of his/her counterparts. In contrast, the scores show that relationship continuity is the second highest score for asset owners from the Zandhazenbrug. This could be explained by the difference on the type of relationship between owners from one project to the other. Rijkswaterstaat and

Prorail are organizations that recognize as important the continuity of the relationship in the future between each other because of the many different projects that the two owners will continue to have in the future. Whereas the underlying reason that the owners from the Meanderende Maas recognize shared vision as the second highest criteria might be the fact that having joint working process with common missions and visions is more important for such large coalition of ten stakeholders.

Table 8: Relational Collaborative Capacity

(R). Relational Collaborative Capacity			
#	Criteria	ZandhazenB	Meanderende
r.1	knowledge sharing	0,83	0,81
r.2	positive working climate	1,00	0,94
r.3	shared vision	0,83	0,88
r.4	power sharing	0,83	0,75
r.5	value diversity	0,75	0,75
r.6	relationship continuity	0,92	0,69

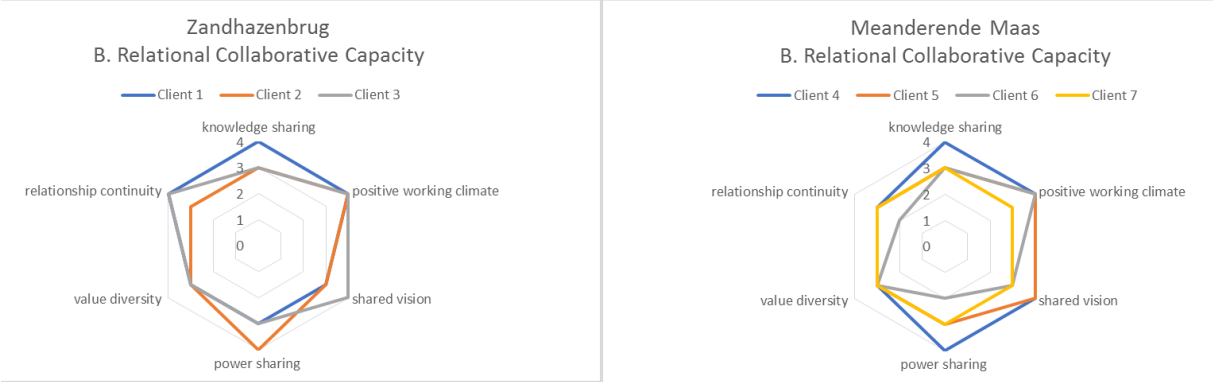

Figure 7: Relational collaborative capacity - Rating Scores from respondent

4.5.3 Organizational Collaborative Capacity

With regards to the organizational collaborative capacity category, the scores were tighter than in the first two categories. Practitioners score 'effective leadership' and 'effective communication' as the two most relevant criteria. The least relevant criterion by respondents is 'promote innovation' with the lowest scores. Although most interviewees rated 'leadership' and 'communication' as most relevant criteria, once interviews were analyzed and coded, it is observed that the most mention criterion was 'formalized procedures', with 24 occurrences (see Appendix C). Therefore, it seems that clients heavily rely on formal agreements to collaborate between clients. What is more, in the words of an interviewee: "it is only natural to have these agreements, without them, the projects would not even exist". The difference between these ratings can be explained by the number of asset owners involved in each project and the different type of complexity the projects present. The Zandhazenbrug involved only two infrastructure owners, which seems that for them the most important criteria is to have effective communication between each other and to build efficient information exchange processes due to the technical complexity of the project. Whereas the Meanderende Maas, consisted of a coalition of ten asset owners, where they seem to value more effective leadership that drive the project team to improve collaboration.

Table 9: Organizational Collaborative Capacity

(O). Organizational Collaborative Capacity			
#	Criteria	ZandhazenB	Meanderende
o.1	effective leadership	0,83	0,88
o.2	effective communication	0,92	0,81
o.3	formalized procedures	0,83	0,81
o.4	sufficient resources	0,67	0,75
o.5	improvement orientation	0,83	0,75
o.6	innovation	0,67	0,63

Figure 8: Organizational collaborative capacity - rating scores from respondents

4.6 Horizontal Collaboration: A comparative analysis of the cases with theory

To what extent the criteria framework constructed from the literature review to assess horizontal collaboration is validated with the two case studies? The study explores which of these criteria are used and recognized by practitioners in the projects and compares them with the theoretical constructs obtained from the literature review. Document review and insights collected form the specific experience of interviewees will be used to validate the criteria.

4.6.1 Individual Collaborative Capacity

As stated before in Chapter 3, individual collaborative skills are among the most important criteria to have in order to build a truly integrated team and have effective collaboration in projects (Bakker, 2018; Foster-Fishman et al., 2001). Considered as preconditions to collaboration, skills such as the ability to work with others, create and build programs, having positive attitude and motivation about yourself and other stakeholders have been identified as key criteria to assess levels of horizontal collaboration. Indeed, having a positive attitude and good motivation to collaborate are considered very important criteria by many representatives of both projects. For instance, most participants argued that individuals have to be capable to understand and communicate their own knowledge to other members of the

team, and perhaps more importantly, to other stakeholders of the project such as inhabitants and other groups affected by the project. Individuals need to know how to collaborate naturally and effectively, otherwise they will not have the opportunity to continue in the process or even join the project team, at all. This is in line with Keast & Hampson (2007) arguments to deactivate or disconnect noncontributing members. In addition, there needs to be a good match between members that do collaborate, but they need to have the right experience in working in complex projects and have the commitment to collaborate.

4.6.2 Relational Collaborative Capacity

Relational collaborative criteria identified to assess horizontal collaboration are knowledge sharing, positive working climate, shared vision, power sharing, value diversity and relationship continuity. All these criteria were positively recognized by practitioners from both projects as reflected in the high rating scores and relative high frequency counts on the interviews as well as in the literature review (See Appendix C). These criteria have been confirmed to be important to assess levels of horizontal collaboration because they stress the benefit of working together at all levels of the relation. Mutual trust that is attributed to network relationships increase by improving communication between clients and having mutual support (Dietrich et al., 2010; Keast & Hampson, 2007; Keung & Shen, 2013). Mutual trust is essential to fill the cushion when unexpected situations and setbacks occur in projects, which are inevitable in complex projects (Ruijter, 2019). Indeed, positive working climate was the criterion rated as most relevant by practitioners from both projects in the IOC matrix and is among the most mentioned by interviews and literature review (see Appendix C). This is because it encompasses important aspects of collaboration, such as cohesion, cooperation, and mutual trust between owners, as well as being open and honest. To confirm this in the content analysis, practitioners from the Zandhazenbrug believe that it is crucial to have mutual trust between commissioning authorities and to work in cohesion for a good, collaborative spirit. This is evident with the fact that both clients, Rijkswaterstaat and ProRail, believe that the collaboration between organizations has improved over the last years, and that both are committed to work together for the good of their projects and the Nation, which is shown through all the projects that both infrastructure owners are currently collaborating jointly. This is particularly important for these two clients, who represent the same Ministry, the Ministry of Infrastructure and Water Management. Similarly, the Meanderende Maas project team considers this criterion the most relevant to assess levels of collaboration. They improved transparency issues and diminished feelings of mistrust by giving access to all documentation, including hard data and by arranging special workshop meetings and “discussion dyke tables” in order to facilitate communication between clients and stakeholders. This is in line with the literature about having shared measurement systems and different communication processes and dialogue spaces to increase levels of trust between actors (Foster-Fishman et al., 2001).

Shared vision is the second criterion most relevant by practitioners from the Meanderende Maas project and the third one for the Zandhazenbrug. This criterion encompasses common understanding of problems, shared solutions and aligned efforts. However, as stated before on the literature review, although it is desirable to have a shared vision between organizations, it is most likely that each organization has its own interest and vision, which are possibly conflicting (Ruijter, 2019). Nonetheless, interviews suggest that in horizontal

collaboration it is possible to have different objectives and visions and still obtain the desired outcomes from working together. This is the case of the Meanderende Maas project, where the coalition of 10 organizations, each with their own interest and vision of the project, had all agreed to a joint-decision making process and created an environment with the right conditions for favorable and productive horizontal collaboration. Furthermore, the fact that there was intensive participation of inhabitants and entrepreneurs of the region, shows that the preferred alternative includes the diverse needs of all stakeholders and interested participants, and that the solution serves as a common strategic purpose (Keast & Hampson, 2007). Similarly, the decision from practitioners of the Zandhazenbrug of having a partner in the other organization as a counterpart of the project to deal with issues and have connections on every level of the project improves collaboration between clients, and is also related with this criterion of shared vision.

The third most mentioned criterion of the framework is knowledge sharing which encompasses knowledge distribution, constant participation of actors at multiple layers of the relationship of organizations, and transfer explicit and tacit knowledge. The testimonies of the practitioners of the Zandhazenbrug about having couples in the other organization as counterparts of the project, and having connections on every level of the project with analogies such as finding connections in the project like a "*zipper*" were very revealing to illustrate the importance of having connections at every level of the organization. Representatives from the Meanderende Maas project echo the importance of knowledge sharing by facilitating information sharing through the development of a communication systems. Clients and stakeholders can have access to all data of the project at any time. In addition, several workshops and discussion spaces were organized to facilitate information sharing among participants of the coalition, stakeholders and other interested parties.

Following is the criterion of power sharing. The criterion consists of encouraging participatory decision-making process, and identified and support network champions. This criterion is supported by insights from both projects but with some nuances. For example, the leading organization of the Meanderende Maas project stated that they wanted to be seen as just one more client, giving the collaborative power to an external Project Manager as the leader, and encouraging decision making processes with the coalition of actors. Similarly, leading managers of the Zandhazenbrug, share power decision making with project specialists by encouraging them to have counterpart couples and by allowing them to make their own decision on important design issues of the project. In this way, collaboration between specialists from both agencies can flow more efficiently.

Value diversity is among the last, but not least criteria mentioned by practitioners of both projects. It includes appreciation of group differences, cultural differences and support of multiple perspectives. It highlights the importance that clients understand and examine the perspectives of other members (Keast & Hampson, 2007). Furthermore, understanding corporate culture is identified as a key indicator to enhance coordination, improve goal alignments between clients and increase members´ efforts (Keung & Shen, 2013). Indeed, officials from the Zandhazenbrug stated that recognizing and being aware of cultural differences was key to anticipate any type of dilemma that might appear over time, especially between Rijkswaterstaat and ProRail, which are two very different organizations with different perceptions and ways of dealing with issues. As Ruijter (2019) argues, it is important

for teams to be able to transcend their own interest to benefit the joint interest that focus on achieving a joint project result. Likewise, representatives of the Meanderende Maas project recognize that it is important to deal with different perspectives by examining the "why, what, and how" levels of the project. Collaboration between clients improves when members can recognize the "why" level. Specifications and regulations are normally described on a "how" level, which can sometimes block the collaboration process; therefore, clients have a joint point of view on the "why" level of the project in order to enhance collaboration between each other.

Turning to the criterion of relationship continuity. It is the second criterion most recognized by practitioners from the Zandhazenbrug project, which encompasses building and maintaining relationships between owners in the future, and the importance of having links with policy makers and other community leaders in order to improve collaboration of projects (Keast & Hampson, 2007; Suprapto, 2016), respondents from both projects stated that, the continuity of the relationship allows them to work and understand other organizational teams. Remarkably, for the Rijkswaterstaat officials, it was important to have a member from ProRail in their IPM team and maintain that relationship through other projects. In that way it kept clients very close and allowed information to flow straightforwardly. It was striking that this criterion was not recognized as important for practitioners of the Meanderende Maas project, being in fourth place of the scores. As discussed earlier, this could be explained by the organizational complexity that this project represent. Dealing with a coalition of 10 organizations, practitioners from this projects gave more relevance to positive working climate and shared vision.

4.6.3 Organizational Collaborative Capacity

Organizational collaborative capacity allows effective implementation of policies, programs and formal agreements between clients. This set of criteria consist of effective leadership, effective communication, formalized procedures, sufficient resources, improvement orientation and innovation. In contrast of the previous category, not all criteria in this category were recognized by practitioners as relevant. The most mentioned criterion and the second highest scored by practitioners in this category was formalized procedures. This criterion was depicted in the clearest terms in both projects. For instance, Rijkswaterstaat and ProRail signed a special collaborative agreement called "Samenwerking-singovereenkomst (SOK)" in order to deal with the high-risk profile and technical complexity of the Zandhazenbrug project. Similarly, the coalition of the Meanderende Maas had several project agreements called "Bestuursovereenkomst" in Dutch, where all the joint-decision making objectives were stated in order to carry out the detail design and the realization phase of the project. In addition, both projects share the MIRT/HWBP system, at national level, which contained the state of affairs of all projects and programs of The Netherlands. In the MIRT system is where the Ministry of Infrastructure and Water Management allocates the funds for the exploration phases of projects, and where all the commitments and agreements are stated with local governments responsible for the project's exploration and realization.

As regards to the criterion of effective communication which encompasses the building of communication processes, problem discussions and resolutions, internal and external communication, this was the highest ranked criterion by practitioners of the Zandhazenbrug

and the second one by representatives from the Meanderende Maas. It was also consistently mentioned during interviews with a high frequency count of 12 (see Appendix C). As Dietrich et al. (2010) argue, effective communication is characterized by sufficient, open and efficient information exchange between collaborative actors. Indeed, communication was very powerful in the Meanderende Maas project through many workshops, discussion tables and other stakeholders meetings, called 'Meanderende Maas Moment (MMM)', which gave clients the opportunity to share their concerns and make questions and comments about the proposed solutions. According to the Project Manager, these meetings were very potent tools for effective communication between clients. Similarly, the fact that a ProRail representative became a team member of the Rijkswaterstaat's IPM team facilitated high levels of communication and encourage mutual supported interaction between both commissioning authorities. Beyond the building of spaces for effective communication, narratives through sense making and sense giving were strategic instruments to foster collaboration and enhance a new type of adaptive partnering, as argued by Ruijter (2019). For instance, the narrative of finding connections like a "zipper" on the project, from an official of Rijkswaterstaat, fostered collaboration within the team.

Following is the criterion of effective leadership. It was highest rated criterion by practitioners from the Meanderende Maas and the second one from the Zandhazenbrug team. This criterion consists of details about driving the relationship to achieve outcomes, the leader is visionary and committed to support collaboration. Practitioners considered this criterion very important to achieve collaboration between clients. As representatives from the Meanderende Maas project stated, an effective and charismatic leader should be able to "*keep the group together by handling over a narrative and giving them the feeling that something special is happening, that every member wants to be part of*". This is in line with Ruijter's (2019) argumentation that leadership should be seen as the management of sense-giving, meaning that leaders can shape the reaction to complex problems by focusing the attention of other members to specific issues and changing their behavior in order to solve problems. Similarly, if specialists have doubts about finding a counterpart because they are afraid to be blamed if something goes wrong, then effective leaders should give them the support and confidence to make the right decision as a specialist, so they can have the freedom to make decisions and collaborate with their counterparts.

Improvement orientation is the next criterion also recognized by practitioners from both projects as necessary for effective collaboration by sharing second place on the scores by the Zandhazenbrug team and third place from the Meanderende Maas project. This criterion seeks inputs from external expertise, develops monitoring systems and adapts to change with resilience capability. As Ruijter (2019) argues that resilience or adaptive capability can be used as a shock-absorbing cushion that must be filled to withstand unexpected situations or setbacks in complex projects. For instance, ProRail recognizes that their project organization is not as clear as the IPM model from Rijkswaterstaat. Therefore, they are in the process of adopting some of the roles from the IPM model to their organization. This is in line with improvement orientation, where actors develop adaptive capacity in their relationships and further respond to feedback and shifting conditions to improve inter-organizational collaboration (Foster-Fishman et al., 2001; Ruijter, 2019). Moreover, the collaborative agreement that included a decision to incorporate a Project Manager from ProRail into the IPM team of Rijkswaterstaat, which allowed ProRail to remain actively involved in the project,

is in line with the vision of Keast & Hampson (2007), regarding introducing new actors to renew interest and change nonperforming dynamics of a working team, which are characterizations of improvement orientation. Similarly, the process of Gate Review, implemented by the external manager of the Meanderende Maas, which involves seeking feedback from external experts on dyke reinforcement and spatial designers is meant to give their opinion and review the preferred alternative.

Finally, sufficient resources and innovation are the least criteria mentioned by respondents, as well as the criteria with the lowest rating scores. It was striking that none of the respondents hinted innovation and sufficient resources as relevant for horizontal collaboration as literature suggests. Ruijter (2019, p 37) states that innovation is born out of necessity in megaprojects because complex conditions require innovative solutions. The implementation of innovation in the construction industry allows for new forms of sharing knowledge and better communication between project team members, which leads to decreases in costs and schedule of projects (Gambatese & Hallowell, 2011). New products, technologies and services that emerge from innovation such as Big Data, Internet of Things and Blockchain technology are playing more important roles in the construction industry (Perera et al., 2020). Given the new challenges and current conditions that the world is facing, including the COVID-19 pandemic, it is important to consider innovative technologies to improve collaboration. However, given that these two criteria were not found relevant to participants in this study, they will not be considered for the final inter-organizational collaboration tool, presented in the following section.

According the respondents and to what has been analysed, the research study finds no other criteria that practitioners consider relevant enough to be included in the study besides the already identified and selected criteria. Rather than mentioning new criteria to be included, some respondents hinted some sub-criteria, which can arguably be already included within the already mentioned criteria. For example, one participant mentioned to include the criterion of a ‘charismatic leader’, which is already covered by the criterion ‘effective leadership’. Another participant mentioned to include the criterion of ‘group member continuity’, which was already covered by the criterion of ‘relationship continuity’.

5. Inter-organizational Collaboration Assessment Tool (ICAT)

5.1 Development of the ICAT

As previously mentioned, upgrading and maintaining interconnecting infrastructures bring great difficulties and challenges to asset managers and owners due to their type of complexities and interdependencies. The body of knowledge shows that effective inter-organizational collaboration is crucial between all actors for the successful completion of projects. Many scholars have studied inter-organizational collaboration with different approaches such as collaborative networks (Keast & Hamptson, 2007; Dietrich et al., 2010), network performance (Keung & Shen, 2013), and inter-organizational relations (Suprapto, 2016).

However, most of the literature is focused on hierarchical relationships (owner-contractor) and the available tools to assess collaboration are based under this context of vertical relationships. This suggests the need to develop a tool that encompasses the context of horizontal collaboration for infrastructure owners to assess how they work together in projects and implement changes in key aspects that the tool would show how they are improving over time. Building on the analytical framework obtained in Chapter 3 and the case study analysis in Chapter 4, a comparative analysis between these two inputs was conducted to select the final criteria to asses inter-organizational collaboration, which are capture in the Inter-Organizational Collaboration Assessment Tool (ICAT). Figure 9 shows the steps of the development of this tool.

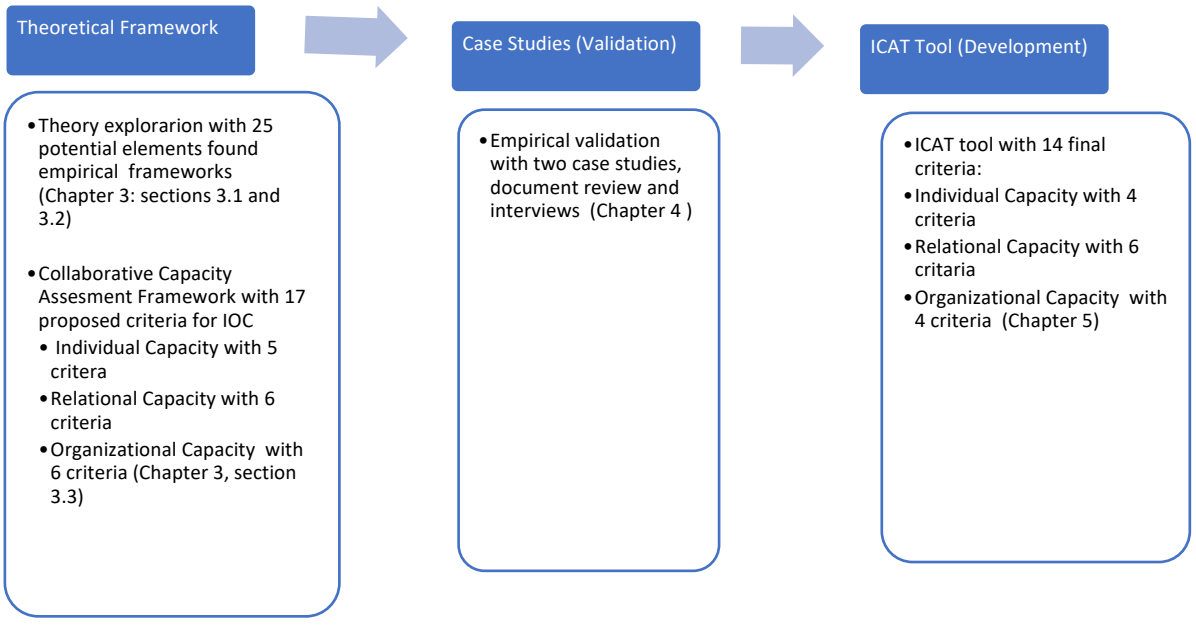

Figure 9: Development of the ICAT

The development of the ICAT started with a systematic analysis of various theoretical frameworks that encompass collaborative networks in Chapter 3, section 3.1. The review of relevant literature identified five sets of criteria with 25 different elements as potential criteria to assess horizontal collaboration in sections 3.2. The elements were: (1) Activating: Forming memberships and accessing resources; (2) Framing: Shifting orientation from single to collective; (3) Mobilizing: Securing commitment to whole or collective identity; (4) Synthesizing: Building and maintaining relationships; (5) roles and process for collaboration; (6) trust between actors; (7) physical and cultural proximity; (8) alignment of incentives; (9) commitment to projects; (10) goal congruence and collaborative goals; (11) conflict resolution; (12) expectation fulfilment; (13) Information exchange; (14) Communication system; (15) Knowledge sharing for collaboration; (16) Corporate culture for promoting networking; (17) Learning capability; (18) Front-end definition; (19) Collaborative practices; (20) Relational attitudes; (21) Team working quality; (22) Project performance; (23) Relationship continuity; (24) Trust & Resilience; (25) Control-management vs Relationship-management. Later, a systematic analysis of the criteria and a comparison with the theoretical review developed by Foster-Fisherman et al. (2001) was elaborated in section 3.3, where 17 criteria remained suited to describe the context of horizontal collaboration. The elements that were excluded from the list were not applicable to horizontal collaboration, and others that had similar definitions were compiled into a single criterion. For example, trust between actors, cohesion, and cooperation were used by several authors with similar descriptions but on different allocations. Thus, these elements were compiled into one criterion for clarity.

A collaborative capacity assessment framework was created in section 3.3, where the 17 criteria was restructured and categorized within three different categories identified: (i) individual capacity, (r) relational capacity, and (o) organizational capacity. The following criteria was selected and included in the framework: (i-1) Ability to work with others; (i-2) Ability to create and build programs; (i-3) Positive attitudes and motivations; (i-4) Positive attitudes about stakeholders; (i-5) Positive attitudes about self; (r-1) Knowledge sharing; (r-2) Positive working climate; (r-3) Shared vision; (r-4) power sharing; (r-5) Value diversity; (r-6) Relationship continuity; (o-1) Effective leadership; (o-2) Formalized procedures; (o-3) Effective communication; (o-4) Sufficient resources; (o-5) Improvement orientation; and (o-6) Innovation.

To validate the collaborative capacity assessment framework, two exploratory case studies were analyzed: the Zandhazenbrug and The Meanderende Maas projects, which were selected because of their similar patterns of interdependencies and collaboration. Document review and insights from experienced practitioners of the Dutch infrastructure industry allowed triangulation with different sources of information about the cases. The comparative analysis shown that 14 out of the 17 criteria of the framework were recognized as relevant and appropriate by practitioners for assessing horizontal collaboration. The criteria that were less relevant to participants were then excluded from the framework, which included: (i-5) Ability positive attitudes about self, (o-4) Sufficient resources and (o-6) Innovation, because the analysis did not find enough evidence to include them in the list and they were not found relevant to participants.

All criteria were rearranged by priority of relevance and broken down into sub-criteria, and indicators. The final ICAT consist of 14 criteria with 30 sub-criteria (4 individual capacity criteria with 6 sub-criteria; 6 relational capacity criteria with 15 sub-criteria; and 4 organizational capacity criteria with 9 sub-criteria). All criteria, sub-criteria, and their corresponding definitions are listed Table 10. Finally, the framework was then translated into the Inter-Organizational Collaboration Assessment Tool (ICAT) (See Table 11).

Table 10: Collaborative Capability Criteria, sub-criteria and definitions of the ICAT

Category	Criteria		Sub-criteria - Indicators	Definitions
(i) Individual Capacity	i.1	Positive attitudes and motivations	Commitment to collaboration, collaborative believes	The individual's ability to hold positive attitudes about collaboration and be committed to the collaboration process
	i.2	Positive attitudes about stakeholders	Respect for different views, trust other stakeholders	The individual's ability to holds positive attitude about stakeholders
	i.3	Ability to work with others	Conflict resolution	The individual's ability to solve conflicts and communicate with others
			Effective communication	The individual's skill to communicate effectively
	i.4	Ability to create programs	Understand targeted problems or interventions	The individual's ability to create an effective program planning and design skills.
			Knowledge in policy and community	The individual's ability to know about the organization´s policy and community
(r) Relational Capacity	r.1	Positive working climate	Cohesion and cooperation	The extent to which the team works together and cooperates as one
			Trust	The extent to which the team trust other teams
			Openness and honesty	The extent to which the team is open and honest with other teams
	r.2	Shared vision	Joint working process (common mission & vision)	The extent to which the team develops a joint working process with common mission and vision.
			Shared solutions and objectives	The extent to which the team shares their best practical solutions and share objectives to collaborate effectively
	r.3	Knowledge sharing	Motivation for knowledge distribution	The extent to which the team encourages knowledge sharing and participation with other teams
			Transfer of explicit and tacit knowledge	The extent to which the team transfers both explicit and tacit knowledge with other project teams
			Development of communication systems	The extent to which the team facilitates information sharing through the development of communication systems
	r.4	Power sharing	Participatory decision-making process	The extent to which the team has participatory decision-making processes between project teams
			Supporting network champions	The ability to support natural leaders (champions) of the project team
	r.5	Relationship continuity	Building and maintaining relationships	The intention to continue the relationship in the future between organizations
			Links with policy makers and other leaders	The extent to which the team builds new relationships and make links with policymakers and other community leaders
	r.6	Value diversity	Group differences appreciated	The extent to which the team accepts group differences in the way of working
			Corporate cultural differences appreciated	The extent to which the team accepts the culture of other organizations
			Multiple perspectives	The ability to perceive other perspectives from team members
(o) Organizational Capacity	o.1	Effective leadership	Excellent senior management	The extent that senior management lead the project team to improve collaboration
			Driving the relation to achieve outcomes	The role that senior management play to drive the relationship for outcomes
	o.2	Effective communication	Internal and external communication	The extent to which the team communicates with each other and with other external teams effectively
			Build communication processes	The extent to build efficient information exchange processes between team members
			Problem discussion and resolution	The extent to participate in problem discussion and resolutions with other teams
	o.3	Formalized procedures	Established formal arrangements	The extent to organize regular meetings among members, delivering ways of collaborating with other members
			Processes of collaboration (rules, values)	The extent to establish joint values, norms, and rules by the organization (new terms of engagement)
	o.4	Improvement orientation	Develop monitoring systems	The extent to develop new monitoring systems to ensure that collaboration between members continues to be directed towards a common strategic purpose
			Responds to change and feedback	The capability (resilience) to adapt and respond to change and feedback for improvement in collaboration

5.2 Inter-Organizational Collaboration Assessment Tool (ICAT)

What is the ICAT?

The final deliverable of this research project is the following Inter-organizational Collaboration Assessment Tool (ICAT), which tries to summarize the main insights drawn from the document review, interviews with owners and evaluation matrix. It is important to note that this is the first attempt of a self-assessment instrument that has the general purpose of assessing horizontal collaboration in infrastructure projects, and more specifically, collaboration between owners or asset managers. Although the information from this tool could have many uses, two stand out:

1. The ICAT can aid inter-organizational project teams of infrastructure owners in identifying areas of improvement in collaboration, and

2. The ICAT can provide a monitoring of the improvements in inter-organizational collaboration by being administered at three points in time, for instance, at the exploratory development, the design phase, and the execution phase of projects.

5.3 Proposed Operationalization of the ICAT

The ICAT requires the active participation of the project team members, stakeholders and senior management of infrastructure projects. This section explains how it is administered to practitioners.

Who Administer the ICAT?

Ideally, the facilitator of the ICAT would be someone who is a researcher or an outside expert to ensure objectivity when assessing horizontal collaboration in the project. The facilitator needs to have a good understanding of the criteria and their definitions covered by the ICAT because participants may have questions and the ICAT might be needed to fine-tune the type of project or industry.

Before administering the ICAT, the facilitator needs to read the ICAT thoroughly to make sure he or she understands each category, criterion and sub-criterion. It is advised that the facilitator complete the ICAT as participants would do, so that he/she can understand the experience of completing the ICAT.

How are Participants Identified?

Identifying participants is the most important part of making sure that the ICAT accurately assess levels of collaboration between owners. The number of participants will depend on the type and size of the infrastructure project and number of owner organizations involved in the project.

If other stakeholders are involved in the project, the researcher or external expert needs to identify the key entities that are involved in the design phase of the project and if they can be considered as an owner. Each of these organizations would receive an invitation to the ICAT administration, specifying that high level and technical personnel involved in design activities would participate in the ICAT.

The ICAT needs to be filled by staff who have experience working at the project. The people invited to participate in the ICAT need to have a range of experience in the infrastructure industry and include high and mid-level managers, as well as team members. It is important to have a diversity of levels because each may have a different expertise on functioning details. The following are guidelines for the types of people who need to fill the ICAT (see Table 11):

- Portfolio managers
- Project managers
- Stakeholder manager
- Contract managers
- Technical managers

Table 11: Inter-organizational Collaboration Assessment Tool (ICAT)

Inter-organizational Collaboration Assessment Tool (ICAT)				
Please rate the following criteria by assigning a score of 1 = Very Poor, 2 = Poor, 3 = Moderate, 4 = Good, 5 = Very Good; alternatively NA = not applicable or DK = do not know.				
#	Criteria	Rating Scores		COMMENT
(I). Individual Skills and Managerial Capacity				
i.1	**Positive attitudes and motivations**			
i.1.1	The individual has positive attitude and is committed to the collaboration process of the project.			
i.2	**Positive attitudes about stakeholders**			
i.2.1	The individual respects different views, cultures and trust other stakeholders			
i.3	**Ability to work with others**			
i.3.1	The individual is able to deal constructively with conflict			
i.3.2	The individual has skills on effective communication			
i.4	**Ability to create and build programs**			
i.4.1	The individual understands targeted problems or interventions			
i.4.2	The individual is knowledgeable about policy and community			
(R). Relational Collaborative Capacity				
r.1	**Positive working climate**			
r.1.1	We have cohesion between project teams and work together as one			
r.1.2	We have mutual trust between project teams			
r.1.3	We are open and honest with other team members			
r.2	**Shared vision**			
r.2.1	We have a joint working process and shared a common mission and vision			
r.2.2	We share our solutions with other teams and align our objectives between teams to collaborate effectively			
r.3	**Knowledge sharing**			
r.3.1	We motivate knowledge distribution and participation with other teams			
r.3.2	We are able to transfer explicit and tacit knowledge with other project teams			
r.3.3	We have a communication system able to facilitate high levels of information sharing			
r.4	**Power sharing**			
r.4.1	We have a participatory decision-making process between project teams			
r.4.2	We support champions (natural leader of the group) for the collaborative process			
r.5	**Relationship continuity**			
r.5.1	We build and maintain relationships between other stakeholders			
r.5.2	There are links with others out of the project (policy makers and community)			
r.6	**Value diversity**			
r.6.1	Group differences are appreciated by the team			
r.6.2	The project team understands and examines the perspectives of other teams			
r.6.3	Corporate cultural differences are appreciated by the team			
(O) Organizational Collaborative Capacity				
o.1	**Effective leadership**			
o.1.1	Senior management is driving the relation to achieve outcomes			
o.1.2	Senior management is visionary and committed to support collaboration			
o.2	**Effective communication**			
o.2.1	We communicate with each other and with other external teams effectively			
o.2.2	We have is a communication process built between project teams			
o.2.3	We participate in problem discussion and resolution with other teams			
o.3	**Formalized procedures**			
o.3.1	There are established and appropriate formal arrangements (agreements, workshops, meetings with other teams)			
o.3.2	There are established values, norms and rules (new terms of engagement)			
o.4	**Improved orientation**			
o.4.1	We have developed a monitoring system to ensure collaboration continues to be directed towards a common strategic purpose			
o.4.2	We have a process of adaptive capability (resilience) to respond to change and feedback for improvement in collaboration			

6. Conclusions & Discussions

6.1 Conclusions

This research project addresses the current challenges that asset managers are facing to efficiently upgrade and maintain the functionality and quality of their infrastructures. As projects become more complex with more interdependencies among multiple clients, more attention has been paid to inter-organizational collaboration (IOC) to improve project performance and reduce fragmentation of the construction industry. The study focuses on identifying the required criteria to assess levels of effective IOC and deliver an Inter-organizational Collaboration Assessment Tool.

The main research question of this study, posed in Chapter 2, reads as follows:

How can integrated collaboration between infrastructure owners be assessed on infrastructure projects?

An answer to the main research question has been found by conducting a literature review and case study research and an in-depth analysis of two cases, using document review and key-informant interviews. The literature review was conducted in order to create theoretical constructs of horizontal collaboration to identify appropriate criteria to assess levels of collaboration between infrastructure owners in the design phase of projects.

In order to answer the main research question, the defined sub-questions are answered, as follows:

1. **What criteria to assess effective inter-organizational collaboration are currently considered in infrastructure projects?**

The literature review identified several theoretical frameworks that cover the concept of collaborative networks in infrastructure projects. These frameworks were identified in different bodies of knowledge such as literature on joint ventures, strategic alliances, network performance and resilient partnerships. To be applicable in the specific context of horizontal collaboration between infrastructure owners, the research focused on literature and sets of criteria identified in literature which focuses on social relationships and interdependencies such as those found in long-term social network theory. This literature identifies the importance of criteria for successful inter-organizational collaboration such as knowledge sharing, effective communication, and adaptive capacity.
The literature search was focus on the infrastructure industry. The number of refereed studies were selected based on the following criteria:

- The article includes a theoretical framework for collaborative networks.
- The article includes evaluation criteria for collaboration.
- The article addresses infrastructure industry.

Once the article fulfilled the required criteria, a total of 20 different articles related to the infrastructure industry were considered. Of these, five empirical articles and one theoretical articles were selected for further in-depth content analysis and comparison to the exploratory case studies. After reading and doing a systematic analysis, 25 elements have been identified in the theoretical frameworks from the selected literature. The potential criteria to assess levels of collaboration between infrastructure owners are: (1) Activating: Forming memberships and accessing resources; (2) Framing: Shifting orientation from single to collective; (3) Mobilizing: Securing commitment to whole or collective identity; (4) Synthesizing: Building and maintaining relationships; (5) roles and process for collaboration; (6) trust between actors; (7) physical and cultural proximity; (8) alignment of incentives; (9) commitment to projects; (10) goal congruence and collaborative goals; (11) conflict resolution; (12) expectation fulfilment; (13) Information exchange; (14) Communication system; (15) Knowledge sharing for collaboration; (16) Corporate culture for promoting networking; (17) Learning capability; (18) Front-end definition; (19) Collaborative practices; (20) Relational attitudes; (21) Team working quality; (22) Project performance; (23) Relationship continuity; (24) Trust & Resilience/Adaptive capacity; (25) Control-management vs. Relationship-management.

The proposed categorization is adapted from the result of intensive literature review on the subject of building collaborative capacity in community coalitions, developed by Foster-Fisherman et al (2001), and the criteria is further refined to be applicable in the specific context of horizontal collaboration. Whit this, a collaborative capacity assessment framework was proposed, where the 17 criteria was restructured and categorized within three different categories identified: (1) individual capacity, (2) relational capacity, and (3) organizational capacity. The following criteria was selected and included in the framework: (i-1) Ability to work with others; (i-2) Ability to create and build programs; (i-3) Positive attitudes and motivations; (i-4) Positive attitudes about stakeholders; (i-5) Positive attitudes about self; (r-1) Knowledge sharing; (r-2) Positive working climate; (r-3) Shared vision; (r-4) power sharing; (r-5) Value diversity; (r-6) Relationship continuity; (o-1) Effective leadership; (o-2) Formalized procedures; (o-3) Effective communication; (o-4) Sufficient resources; (o-5) Improvement orientation; and (o-6) Innovation.

2. How can these criteria be adjusted to analyse effective collaboration between infrastructure owners in Dutch infrastructure projects?

The answer to this sub-question was based on the interviews with 9 key informant stakeholders from 8 different Dutch organizations. The interviews, conducted from March to May 2020, were individual open-ended, semi-structured questions with the chance of having a wide range of respondents and allowed them for in-depth exchanges of contextual knowledge. Previously, an established protocol was shared with the interviewees to provide the respondents with general information of the research project and a guide of the semi-structured questions (see Appendix A). The background of the interviewees hold a balanced and diverse set of positions and ample experience in managing engineering projects. In addition, a predetermined IOC Criteria Assessment Evaluation Matrix was sent to respondents on a separate e-mail for their rating by assigning a score of 1: Most Disagree, 2: Disagree, 3: Agree, 4: Most agree (see Appendix B).

The results of the interviews showed that the criterion most frequently mentioned by respondents, related to individual capacity, was 'positive attitude and motivation' with 9 mentions (see Appendix C), which coincides with the results of the IOC rating matrix, where the highest individual skills criterion is 'positive attitude and motivations' with a perfect score of 1 for the Zandhazenbrug and 0.88 for the Meanderende Maas. This shows that most participants from both projects rated these set of criteria similarly, agreeing that holding a positive attitude and being committed to collaboration is very important to collaborate effectively between asset owners. The most noticeable difference in the scores is from Client 4 of the Meanderende Maas project. The respondent gave a score of zero to criterion (i.5) (see Figure 6). This gave the lowest score to this criterion (0.56), and also was the least mentioned in the interviews (see Appendix C).

Relational collaborative capacity results show that 'positive working climate' as the most relevant criterion with a perfect score of 1 for the Zandhazenbrug project and 0.94 for the Meanderende Maas, followed by 'shared vision' with 0.88 in the case of the Meanderende Maas project and 'relationship continuity' with 0.92 for the Zandhazenbrug.). Evidently, the overall scores show that practitioners consider that having a positive working climate through cooperation, cohesion and with mutual trust between owners is very important for effective horizontal collaboration. Most criteria are rated with high scores, with exception of scores from Client 6 with low scores to relationship continuity and power sharing in the Meanderende Maas project. The difference of scores between client 6 and the other partners show that participatory decision making and the intention to continue the relationship between organizations seems not as important for this asset owner as for the rest of his/her counterparts. In contrast, the scores show that relationship continuity is the second highest score for asset owners from the Zandhazenbrug. This explains that Rijkswaterstaat and Prorail are organizations that recognize as important the continuity of the relationship in the future between each other because of the many different projects that the two owners will continue to have in the future. Whereas owners from the Meanderende Maas recognize shared vision as the second highest criteria might be the fact that having joint working process with common missions and visions is more important for such large coalition of ten stakeholders.

As regards to the organizational collaborative capacity category, practitioners score 'effective leadership' and 'effective communication' as the two most relevant criteria. The least relevant criterion by respondents is 'promote innovation' with the lowest scores. Although most interviewees rated 'leadership' and 'communication' as most relevant criteria, once interviews were analyzed and coded, it is observed that the most mention criterion was 'formalized procedures', with 24 occurrences (see Appendix C). Therefore, it seems that clients heavily rely on formal agreements to collaborate between clients. What is more, in the words of an interviewee: "it is only natural to have these agreements, without them, the projects would not even exist". The difference between these ratings can be explained by the number of asset owners involved in each project and the different type of complexity the projects present. The Zandhazenbrug involved only two infrastructure owners, which seems that for them the most important criteria is to have effective communication between each other and to build efficient information exchange processes due to the technical complexity of the project. Whereas the Meanderende Maas, consisted of a coalition of ten asset owners, where they seem to value more effective leadership that drive the project team to improve

collaboration. Given that these two criteria were not found relevant to participants in this study, they will not be considered for the final inter-organizational collaboration tool, presented in the following section.

3. **How can criteria to analyse effective inter-organizational collaboration be transformed into a collaborative assessment tool for teams from different infrastructure owners in Dutch infrastructure projects?**

The answer to this question is the development of the Inter-organizational Collaboration Assessment Tool (ICAT). It started with a systematic analysis of various theoretical frameworks that encompass collaborative networks in Chapter 3, section 3.1. The review of relevant literature identified five sets of criteria with 25 different elements as potential criteria to assess horizontal collaboration in sections 3.2. Later, a systematic analysis of the criteria and a comparison with the theoretical review developed by Foster-Fisherman et al. (2001) was elaborated in section 3.3, where 17 criteria remained suited to describe the context of horizontal collaboration. The elements that were excluded from the list were not applicable to horizontal collaboration, and others that had similar definitions were compiled into a single criterion. For example, trust between actors, cohesion, and cooperation were used by several authors with similar descriptions but on different allocations. Thus, these elements were compiled into one criterion for clarity. Next, a collaborative capacity assessment framework was created in section 3.3, where the 17 criteria was restructured and categorized within three different categories identified: (i) individual capacity, (r) relational capacity, and (o) organizational capacity. Finally, to validate the assessment framework, two exploratory case studies were analyzed: the Zandhazenbrug and The Meanderende Maas projects, which were selected because of their similar patterns of interdependencies and collaboration. Document review and insights from experienced practitioners of the Dutch infrastructure industry allowed triangulation with different sources of information about the cases. The comparative analysis shown that 14 out of the 17 criteria of the framework were recognized as relevant and appropriate by practitioners for assessing horizontal collaboration. All criteria were rearranged by priority of relevance and broken down into sub-criteria, and indicators. The final ICAT consist of 14 criteria with 30 sub-criteria (4 individual capacity criteria with 6 sub-criteria; 6 relational capacity criteria with 15 sub-criteria; and 4 organizational capacity criteria with 9 sub-criteria). All criteria, sub-criteria, and their corresponding definitions are listed Table 10. Finally, the framework was then translated into the Inter-Organizational Collaboration Assessment Tool (ICAT).

The tool consists of (i.1) positive attitude and motivation, (i.2) positive attitude about stakeholders, (i.3) ability to work with others, and (i.4) ability to create and build programs. Then it follows with (r) relational collaborative capacity, which includes six criteria: (r.1) positive working climate, (r.2) shared vision, (r.3) knowledge sharing, (r.4) power sharing, (r.5) relationship continuity, and (r.6) value diversity. Finally, it ends with (o) organizational collaborative capacity, which consist of four different criteria: (o.1) effective leadership, (o.2) effective communication, and (o.3) formalized procedures, and (o.4) improved orientation.

The tool is to be administered ideally by a researcher or an outside expert to ensure objectivity when assessing horizontal collaboration in the project. The facilitator should have

a good understanding of the criteria covered by the ICAT because it might needed to be fine-tuned to the type of project or industry.

6.2 Discussions

6.2.1 Scientific implications of the research

A knowledge gap was established at the beginning of this research study. The existing body of knowledge shows a significant number of studies and a wide range of approaches to analyze IOC on a hierarchical perspective. However, there are a few studies that cover the required criteria to measure levels of horizontal collaboration, and most of their theoretical frameworks are focused within a 'client-to-contractor' perspective, without considering the relations between clients only (De Ridder & Noppen, 2009; Suprapto, 2016; Ruijter, 2019). This research tries to narrow the literature gap by focusing on horizontal relationships with a 'client-to-client' perspective. It establishes criteria that assess levels of collaboration in the design phase of infrastructure projects, by providing an integrated collaborative assessment tool for asset managers of the Dutch infrastructure industry to assess their levels of collaboration.

The scientific applicability of this study can be visualized by the comparison made between how frequently the selected criteria are mentioned in the literature review and compares them with the frequency mentioned by key-informant interviewees. All frequencies, as seen in Appendix C, were calculated using the aid of the qualitative analysis software ATLAS.ti, and show that most of the criteria selected from literature review were mentioned by practitioners of the Dutch infrastructure industry. The results show similar number of criteria mentioned that are relative to interviews, as well as relative to literature.

6.2.2 Practical implications of the research study

The practical applicability of this research project is achieved by the final deliverable of the thesis, the Integrated Collaborative Assessment Tool (ICAT), found on Chapter 6, section 6.4. The tool, built upon theoretical constructs, analyzed and validated with two exploratory case studies, has a number of practical implications. The tool can be used by asset managers and practitioners that represent asset owner of the Dutch infrastructure industry to evaluate their levels of collaboration in the design phase of projects and adjust their practices to improve project performance.

6.2.3 Limitations of research study

This research project encountered two important limitations. First, interviews were rescheduled, and others cancelled, and they had to be conducted via Skype or phone due to the COVID-19 pandemic. While this has not affected the quality of the research, it provoked several delays, and in some cases, it was more challenging to connect and build rapport with the interviewees and reduced the possibility to analyze their body language.

Another limitation was regard to documents collection. The request of internal documents, not available online was particularly difficult. Some interviewees were, sometimes, reluctant to share information, arguing that they would need previous authorization from other colleagues. Other participants have stated that they do not have access to the documents anymore because the project has been finished years ago and they are now working in other projects. However, the researcher was able to obtain documentation, such as electronic records, formal agreements, policy briefs, and workshop meetings that allowed triangulating evidence from multiple sources.

6.2.4 Recommendations and reflections

Since this study is an initial attempt to determine the required criteria to assess levels of collaboration between clients in Dutch infrastructure projects, further research studies are recommended in order to gain more knowledge in the field. First, the collaborative assessment framework could be applied for different type of projects and industries with significant influences outside the country, for example, the oil and gas industry, with its necessary adjustments to the tool. Second, the assessment tool can be applied to other countries, considering cultural elements and local conditions, such as differences in institutions, the prevalence of informal practices and arrangements, and poor governance. Finally, future studies could use the same collaborative assessment framework to replicate the study with a larger set of samples and more research resources.

This research reveals that asset managers need the knowledge of new soft mechanisms of social and cultural collaboration to deal with the increased complexity and dependencies of their infrastructure projects. Clients need to pay attention to their collaborative capacity at three different levels: individual, relational and organizational capacity in order to improve project performance.

This study contributes to the theoretical literature on horizontal collaboration as well as to assess levels of effective integrated collaboration between clients proposing an analytical tool (ICAT). Even though the tool has been drawn from the validation and analytical generalization of theory with only two cases studies due to resources and time constrains, this project finds nevertheless that the most important criteria related to assess horizontal collaboration have been accurately included in the tool. However, as mentioned elsewhere this is the first attempt of this self-assessment tool that will need to be further developed and piloted in order to be adjusted to other projects for further validation.

To what extent can these criteria be generalized to assess effective inter-organizational collaboration in other infrastructure projects?

Every project is somewhat unique. The development of collaborative practices may vary according to the nature of the project, the type of complexity, the types and number of organizations involved, and their interdependencies. Yet in some ways, the patterns of horizontal collaboration can be examined and understood with the criteria identified by this research study. Nevertheless, it is important to note that these criteria should be customized to other geographical areas and type of industry in order to take into consideration specificities of countries' governance, culture and domestic politics.

These criteria provide a generalized framework to assess levels of collaboration between infrastructure operators and have been derived from broader theoretical approaches and the empirical insights from the case studies. They provide an appropriate and useful venue to examine and assess effective horizontal collaboration.

The two case studies, the Zandhazenbrug and the Meanderende Maas, do not provide an open-and-end case for establishing the criteria to assess levels of collaboration. Quite the opposite, they provide an initial venue for testing the relevance of the criteria framework in different type of projects with new case studies. Thus, the findings of this study hold important implications for inter-organizational collaboration research more generally.

In sum, from the analytical generalization of the data in this research project, successful horizontal collaboration criteria can be generalized as hard conditions and soft conditions. The hard conditions are the formal agreements, participatory gatherings and individual skills required for effective collaboration between clients, where commitments and agreements are specified, along with who is responsible for the technical and financial aspects. The soft conditions are the relational and organizational aspects of horizontal collaboration, such as knowledge sharing, positive working climate, shared vision, value diversity, effective leadership and communication, and improvement orientation.

7. Literature List

Bakker, H. (2018). Introduction. In H. Bakker & J. de Kleijn (Eds.), Projects and People - Mastering Success (pp. 3-15). Nijkerk: NAP - Process Industry Network.

Bosch-Rekveldt, M., Jongkind, Y., Mooi, H., Bakker, H., & Verbraeck, A. (2011). Grasping project complexity in large engineering projects: The TOE (Technical, Organizational and Environmental) framework. *International Journal of Project Management, 29*(6), 728-739.

Bryan, T. K. (2011). *Exploring the dimensions of organizational capacity for local social service delivery organizations using a multi-method approach.* Virginia Tech,

Camarinha-Matos, L. M., Afsarmanesh, H., & Ollus, M. (2008). *Methods and tools for collaborative networked organizations*: Springer.

Clegg, S. R., Sankaran, S., Biesenthal, C., & Pollack, J. (2017). Power and sensemaking in megaprojects. In The Oxford handbook of megaproject management (pp. 238-258). Oxford: Oxford University Press.

Cropper, S., Ebers, M., Huxham, C., & Ring, P. S. (2008). *The Oxford handbook of inter-organizational relations*: Oxford Handbooks.

Daley, D. M. (2008). Interdisciplinary problems and agency boundaries: Exploring effective cross-agency collaboration. *Journal of Public Administration Research and Theory, 19*(3), 477-493.

Davies, A., & Mackenzie, I. (2014). Project complexity and systems integration: Constructing the London 2012 Olympics and Paralympics Games. International journal of project management, 32(5), 773-790.

De Meanderende Maas. (2020, May 4). Home. Retrieved from https://www.meanderendemaas.nl

De Bruijn, H., & Ten Heuvelhof, E. (2010). *Process management: why project management fails in complex decision making processes*: Springer Science & Business Media.

De Bruijn, H., & Ten Heuvelhof, E. (2018). *Management in networks*: Routledge.

De Ridder, H., & Noppen, J. (2009). Design and Construct in Civil Engineering. In: Delft: TUDelft.

De Meanderende Maas. (2020, May 4). Home. Retrieved from https://www.meanderendemaas.nl

Dietrich, P., Eskerod, P., Dalcher, D., & Sandhawalia, B. (2010). The dynamics of collaboration in multipartner projects. Project Management Journal, 41(4), 59-78.

Dyer, J. H., & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: the Toyota case. *Strategic management journal, 21*(3), 345-367.

Emuze, F., & Smallwood, J. J. (2014). Collaborative working in South African construction: contractors' perspectives. *Journal of Engineering, Design and Technology, 12*(3), 294-306.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. Qualitative inquiry, 12(2), 219-245.

Flyvbjerg, B. (2013). Over budget, over time, over and over again: Managing major projects.

Foster-Fishman, P. G., Berkowitz, S. L., Lounsbury, D. W., Jacobson, S., & Allen, N. A. (2001). Building collaborative capacity in community coalitions: A review and integrative framework. *American journal of community psychology, 29*(2), 241-261.

Fountain, J. E. (2001). The virtual state: Transforming American government? *National Civic Review, 90*(3), 241-252.

Gambatese, J. A., & Hallowell, M. (2011). Enabling and measuring innovation in the construction industry. Construction Management and Economics, 29(6), 553-567.

Gil-Garcia, J. R. (2013). Towards a smart State? Inter-agency collaboration, information integration, and beyond. *ICT, public administration and democracy in the coming decade, innovation and the public sector series, 20*, 59-70.

Gil-Garcia, J. R., & Sayogo, D. S. (2016). Government inter-organizational information sharing initiatives: Understanding the main determinants of success. *Government Information Quarterly, 33*(3), 572-582.

Hertogh, M., & Westerveld, E. (2010). *Playing with complexity : management and organisation of large infrastructure projects = Spelen met complexiteit*. Rotterdam: Erasmus Univ.

Hertogh, M. J., Bakker, J. D., van der Vlist, M. J., & Barneveld, A. S. (2018). Life cycle management in upgrade and renewal of civil infrastructures. *Organization, technology & management in construction: an international journal, 10*(1), 1735-1746.

Iv-Groep. (2017, January 1). Steel Going Strong. *IVORMATIE MAGAZINE* , *31*(1), 19–25.

Integraal projectmanagement. (2019, October 24). Retrieved from https://www.rijkswaterstaat.nl/zakelijk/zakendoen-met-rijkswaterstaat/werkwijzen/werkwijze-in-gww/werken-in-projecten/integraal-projectmanagement.aspx

Kale, P., Singh, H., & Perlmutter, H. (2000). Learning and protection of proprietary assets in strategic alliances: Building relational capital. *Strategic management journal, 21*(3), 217-237.

Keast, R., & Hampson, K. (2007). Building constructive innovation networks: Role of relationship management. *Journal of Construction Engineering and Management, 133*(5), 364-373.

Keung, C. C., & Shen, L.-y. (2013). Measuring the networking performance for contractors in practicing construction management. *Journal of Management in Engineering, 29*(4), 400-406.

Latham, M. (1994). Constructing the Team: Joint Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry, Final Report, HMSO, London.

Lavikka, R. H., Smeds, R., & Jaatinen, M. (2015). Coordinating collaboration in contractually different complex construction projects. *Supply chain management: an international journal*.

Love, P. E., Irani, Z., Cheng, E., & Li, H. (2002). A model for supporting inter-organizational relations in the supply chain. *Engineering Construction and Architectural Management, 9*(1), 2-15.

MIRT Overzicht. (2016, September 21). Retrieved May 10, 2020, from http://mirt2016.mirtoverzicht.nl

Norris, M., & Oppenheim, C. (2007). Comparing alternatives to the web of science for coverage of the social sciences' literature. Journal of Informetrics, 1(2), 161–169. https://doi.org/10.1016/j.joi.2006.12.001

Oliver, A. L., & Ebers, M. (1998). Networking network studies: an analysis of conceptual configurations in the study of inter-organizational relationships. *Organization studies, 19*(4), 549-583.
Perera, S., Nanayakkara, S., Rodrigo, M. N. N., Senaratne, S., & Weinand, R. (2020). Blockchain technology: Is it hype or real in the construction industry?. Journal of Industrial Information Integration, 17, 100125.
ProRail. (2017, December). Network Statement 2019 (T20160098-1656408669–827). Delft, Netherlands: Author.
Rossignoli, C., & Ricciardi, F. (2015). *Inter-organisational relationships*: Springer.
Ruijter, H. A. (2019). *Resilient Partnership.* VU University Amsterdam, (978 90 90 31546 1)
Rijkswaterstaat. (2020b, June 2). Home. Retrieved from https://www.rijkswaterstaat.nl/index.aspx
Suprapto, M. (2016). Collaborative contracting in projects.
Shelbourn, M., Bouchlaghem, N. M., Anumba, C., & Carrillo, P. (2007). Planning and implementation of effective collaboration in construction projects. Construction Innovation.
Shokri-Ghasabeh, M., & Kavoousi-Chabok, K. (2009). Generic project success and project management success criteria and factors: Literature review and survey (Doctoral dissertation, World Scientific and Engineering Academy and Society).
Ting, M. M. (2011). Organizational Capacity. *Journal of Law, Economics, & Organization, 27*(2), 245-271.
van den Brand, P. W. H. L. (2020). Never a dull moment: governance of dike reinforcement and river widening in the project Meandering Meuse. Managing changing rivers: NCR Days 2020 Proceeding.
Waterstaat, M. V. I. E. (2017, 19 September). Increasing mobility in a more sustainable 	country. Retrieved from https://www.government.nl/latest/news/2017/09/19/increasing-mobility-in-a-more-sustainable-country
Wermer, F. (2018). De kracht van een driehoek - Praktijkervaringen met Integraal Projectmanagement (IPM). Retrieved from https://neerlandsdiep.nl/wp-content/uploads/2018/10/Kracht-van-een-Driekhoek_Freek-Wermer_oktober-2018.pdf
Zucker, L. G. (1987). Institutional theories of organization. Annual review of sociology, 13(1), 443-464.

8. Appendices

Appendix A: Protocol - Conversation guide for research project: *Effective Inter-Organizational Collaboration for Interconnecting Infrastructures.*

Purpose of the interview: This conversation is being held in the context of a Thesis Research Project conducted by Mauricio David Pico Parra, in fulfilment for the degree of Master of Construction and Engineering (CME) at TU Delft. The research project aims to assist the NWO-funded research project called "Using data streams to support the integrated design of interconnecting infrastructures".

The purpose of this research is to investigate the required criteria to stimulate levels of effective inter-organizational collaboration across multi-client teams in the design phase of infrastructure projects. It aims to develop an integrated collaborative assessment tool with a client-to-client perspective. The research will be examined through the lens of exploratory case studies. The selection of the cases will be based on the interdependencies of infrastructure asset managers.

Confidentiality: All the information obtained through the interview will be used for academic purpose only. The researcher would like to record the conversation for his own use. If required, a conversation report can be sent. The interviews and all data and information obtained through the interviews remain confidential and will not be shared with third parties. The researcher can process information from the interview in abstracted form in the final thesis report, but the information will not be traceable to individual respondents. In all other cases, the interviewee will be asked in advance for approval and permission to reproduce the passage in the report.

The interview will be held preferably in English, however if the respondent feels more comfortable to speak in Dutch, it can be arranged to have a Dutch speaking person present at the interview.

Definitions: Inter-organizational collaboration (**IOC**) is a process between people or organizations that interact with each other at horizontal levels for common goals by sharing knowledge, learning and building consensus. The research focuses particularly in the design phase of interconnecting infrastructure projects. Reinforcing the capacity of collaborative multi-client teams and creating the necessary conditions for making them an endogenous reality, are key elements for successful infrastructure projects.

The research question: The following research question is formulated in the research project:

How can integrated collaboration between clients be assessed on infrastructure projects?

After a short introduction, we want to ask you in the conversation about your knowledge of inter-organizational collaboration in the following four parts.

1. Background of the Organization

1.1. What experience does your organization have with IOC between multi-client teams on infrastructure projects?
1.2. As a client of the project, how do you describe the collaboration process between your own team and other client teams in the design phase of a project?
1.3. How do you describe the collaboration between RWS and Prorail in this project (the Zandhazen brug)?
1.4. Was it successful collaboration? Why?
1.5. Do you use your own experience and knowledge to collaborate or do you use others experience and knowledge to collaborate between multi-client teams?
1.6. How would you assess IOC in your organization according to your experience?

2. Relational Collaborative Capacity

2.1. What type of criteria would you recognize to evaluate levels of relational collaborative capacity?
2.2. How would you view the criteria selected by us?
2.3. Which of these criteria do you consider relevant? And would you include or any other relevant criteria?

3. Organizational Collaborative Capacity

3.1. What type of criteria would you recognize in your organization to evaluate levels of organizational collaborative capacity?
3.2. How would you view the criteria selected by us?
3.3. Which of these criteria do you consider relevant? and would you add any other relevant criteria?

Appendix B: IOC Criteria Evaluation Matrix

IOC Capacity Assessment Framework						
Please rate the following criteria by assigning a score of 1: Most Disagree, 2: Disagree, 3: Agree, 4: Most agree. Alternatively you may answer NA: not applicable						
A. Individual Skills and managerial capacity (Preconditions to IOC)						
#	**Criteria**	**Definition**	Most agree	Agree	Dis-agree	Most Dis-agree
			4	3	2	1
1	ability to work with others	Conflict resolution, effective communication, knowledge about norms				
2	ability create and build programs	Understand targeted problems or interventions, knowledge in policy, politics and community				
3	positive attitudes and motivations	Committed to collaboration, collaborative believes (goals, production)				
4	positive attitudes about stakeholders	respect different views, trust other stakeholders				
5	positive attitudes about self	select relevant and capable members, innate expertise and knowledge bases.				
B. Relational Collaborative Capacity						
#	**Criteria**	**Definition**	Most agree	Agree	Dis-agree	Most Dis-agree
			4	3	2	1
6	knowledge sharing	motivate knowledge distribution and participation. Transfer explicit and tacit knowledge				
7	positive working climate	Cohesive, cooperative, trust, open and honest, mutual support				
8	shared vision	Common understanding of problems and shared solutions, aligned efforts				
9	power sharing	Participatory decision-making process, support network champions…				
10	value diversity	Group differences appreciated, multiple perspectives				
11	relationship continuity	Build and maintain relationships, links with others out of the network, policy makers				
	would you include any other criteria, not included here, relevant?					
C. Organizational Collaborative Capacity						
#	**Criteria**	**Definition**	Most agree	Agree	Dis-agree	Most Dis-agree
			4	3	2	1
12	effective leadership	Driving the relation to achieve outcomes, visionary and committed to support collaboration				
13	effective communication	Build communication processes Problem discussion and resolution New narratives through sensemaking and sense giving				
14	formalized procedures	Processes of collaboration (rules, values, and norms in the network) Team coordination and integration Contracts/Charters				
15	sufficient resources	Resource organization (physical, material, equipment) Financial and personnel resources				
16	improvement orientation	Develop monitoring systems and adapt change Adaptive capability (Resilience)				
17	promote innovation	Provides innovative services and solutions Introduce new ideas of data sharing				
	would you include any other criteria, not included here, relevant?					

Appendix C: IOC Criteria Frequency Responses from Interviews and Literature Review (source: ATLAS.ti)

(i). Individual capacity (ATLAS.ti)	Interviews			Literature Review			Total
	Absolute	Relative to criteria	Relative to interviews	Absolute	Relative to criteria	Relative to literature	
• Skills-ability to work with others Gr=12	6	50,00%	23,08%	6	50,00%	54,54%	12
• ability create and build programs Gr=5	4	80,00%	15,39%	1	20,00%	9,09%	5
• Skills-positive attitudes and motivations Gr=10	9	90,00%	34,62%	1	10,00%	9,09%	10
• Skills-positive attitude about self Gr=4	3	75,00%	11,54%	1	25,00%	9,09%	4
• Skills-positive attitudes about stakeholders Gr=6	4	66,67%	15,39%	2	33,33%	18,18%	6
Totals	26	100,00%	100,00%	11	100,00%	100,00%	37

(R). Relational Collaborative Capacity (ATLAS.ti)	Interviews			Literature Review			Total
	Absolute	Relative to critera	Relative to interviews	Absolute	Relative to critera	Relative to interviews	
• Knowledge sharing Gr=15	8	53,33%	16,33%	7	46,67%	16,67%	15
• Positive working climate Gr=23	11	47,83%	22,45%	12	52,17%	28,57%	23
• Shared vision Gr=24	16	66,67%	32,65%	8	33,33%	19,05%	24
• Power sharing Gr=11	7	63,64%	14,29%	4	36,36%	9,52%	11
• Value diverity Gr=10	4	40,00%	8,16%	6	60,00%	14,29%	10
• Relationship continuity Gr=8	3	37,50%	6,12%	5	62,50%	11,91%	8
Totals	49	53,85%	100,00%	42	46,15%	100,00%	91

(O). Organizational Collaborative Capacity (ATLAS.ti)	Interviews			Literature Review			Total
	Absolute	Relative to criteria	Relative to interview	Absolute	Relative to criteria	Relative to interview	
• Effecive communication Gr=30	12	40,00%	19,36%	18	60,00%	33,33%	30
• Effective leadership Gr=17	8	47,06%	12,90%	9	52,94%	16,67%	17
• Formalized procedures Gr=36	23	63,89%	37,10%	13	36,11%	24,07%	36
• Improvement orientation Gr=11	7	63,64%	11,29%	4	36,36%	7,41%	11
• Promote innovation Gr=12	8	66,67%	12,90%	4	33,33%	7,41%	12
• Sufficient resources Gr=10	4	40,00%	6,45%	6	60,00%	11,11%	10
Totales	62	53,45%	100,00%	54	46,55%	100,00%	116