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Bridging the knowledge gap

OVERCOMING CHALLENGES RELATED TO KNOWLEDGE MANAGEMENT IN AN INTER-ORGANISATIONAL PROGRAMMATIC APPROACH FOR THE REPLACEMENT- AND RENOVATION OF BRIDGES IN THE NETHERLANDS

MSC THESIS

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OVERCOMING CHALLENGES RELATED TO KNOWLEDGE MANAGEMENT IN AN INTER-ORGANISATIONAL PROGRAMMATIC APPROACH FOR THE REPLACEMENT- AND RENOVATION OF BRIDGES IN THE NETHERLANDS

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Preface

This report is the master thesis "bridging the knowledge gap: overcoming challenges related to knowledge management in an inter-organisational programmatic approach for the replacement and renovation of bridges in the Netherlands". This thesis is written in order to fulfil the requirements of finishing the master Construction Management and Engineering from the TU Delft. This thesis took place between February and August of 2024.

This report can be interesting for people who want to get a better understanding of the practical challenges related to knowledge- and programme management. It could also be interesting for people who want to get to know more about the 'bureau herberekeningen'

I would like to thank my supervisors from the TU Delft, Paul Chan, Leon Hombergen, and Hans Ramler. You have been very helpful in giving me feedback, especially when I was still figuring out what this research should include. The meetings were always very educational and fun.

Furthermore, I would also like everyone at Witteveen+Bos for the good reception resulting me in looking back positively. I specifically would like to thank Arlette Nieswaag for her good guidance and helpful insights. I would also like to thank all the people from Rijkswaterstaat and the engineering firms that were willing to do the interviews and have the conversations with me. This thesis would not have been possible with their willingness to share and their insights.

Please enjoy reading this thesis.

Jochem J. Franken

Delft, September 2024

Abstract

The infrastructure of the Netherlands is mostly built in the 1950s and 1960s and is approaching the end of its theoretical lifespan of 80 to 100 years. Due to more intensive use and increased traffic loads many bridges need to be renovated or replaced. National and regional infrastructure managers, such as Rijkswaterstaat, ProRail, provinces, municipalities, and regional water authorities, are tasked with managing these assets with an estimated replacement and renovation cost of 170 billion euros until 2100, potentially reaching 260 billion euros. To first get an insight however into the state of the bridges in the Netherlands, these bridges need to be constructively recalculated.

This research considers practical challenges and solutions related to knowledge management within an inter-organisational programmatic approach for the replacement and renovation of bridges in the Netherlands. This research therefore considers the 'bureau herberekeningen': a recalculation programme organised by Rijkswaterstaat in which ten engineering firms are involved for the recalculations of more than 250 steel, concrete, and moveable bridges. This research aims to inform on what a programmatic approach can consist of, identify possible challenges related to knowledge management in an inter-organisational programmatic approach, and advice on overcoming these challenges.

A literature study was conducted on three topics: the programmatic approach, knowledge management, and inter-organisational collaboration. The programmatic approach is defined as a combination of related projects managed together to achieve benefits and objectives that cannot be obtained by individual projects. The organisation of a program must consider the interrelation of projects, their characteristics, and the nature of the involved organisations. This results in the need for a programme management office for governance and adaptation. Knowledge management at the programme level involves organising activities and systems to facilitate the identification, storage, retrieval, sharing, and use of knowledge, incorporating both social and codified approaches. Network governance is recommended to support the relations in inter-organisational collaboration, focusing on relationships between programme and project managers, the programme and organisational strategy, and among individual projects, while considering the importance of trust, communication, and collaboration.

The empirical study, conducted in collaboration with the Dutch engineering firm Witteveen+Bos, reveals several critical insights. Key challenges include the need for improved collaboration and communication, overcoming competitive barriers to knowledge sharing, and ensuring efficient and less detailed assignment descriptions to maintain project momentum. The study also highlights the importance of fostering a culture of openness, reciprocity, and trust among involved parties to facilitate effective knowledge management.

The findings suggest that the programmatic approach, when combined with knowledge management, can significantly improve the efficiency and effectiveness of recalculations. Recommendations include using technical assessments between engineering firms for knowledge sharing, organising regular collaboration days, and ensuring the pace and bundling of project assignments to make optimal use of the relations between projects.

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I. Introduction

This section of the report introduces the research by describing the scope, research gap, aim, methodology, questions, and the structure of the report.

Figure I.1: Brug Uitwellgerga

One of the moveable bridges that have been identified by Rijkswaterstaat to be recalculated is the brug Uitwellgerga near Sneek in the Netherlands. Photo: Agnes Monkelbaan

1. Research scope and problem definition

Much of the infrastructure in the Netherlands needs to be renovated or replaced in the following decades (Rasker et al., 2023; Rijkswaterstaat, n.d.-b; Witteveen+Bos, 2023), because:

- Much of the infrastructure in the Netherlands was constructed in the 50's and 60's of the 20th century,
- has been subjected to intensive loads due to more and more heavy traffic throughout the decades, and
- many of these objects were designed with an intended theoretical lifetime of about 80 to 100 years

Together, the national infrastructure managers Rijkswaterstaat and ProRail, the 12 provinces, the 341 municipalities, and the 21 regional water authorities manage tens of thousands of civil objects such as bridges, tunnels, locks, and viaducts, with a total value of 347 billion euros. TNO estimated in 2023 that the costs of the replacement- and renovation task for civil infrastructure objects will be around 170 billion euros until 2100. It will become 260 billion euros if one were to include road foundations and sewers, while still excluding locks, tunnel technical installations and road maintenance, which also contribute enormously to the total costs (Rasker et al., 2023). Some even expected that around 85.000 civil objects need to be replaced or renovated before 2050 (TKI Bouw & Techniek, n.d.).

1.1. The replacement- and renovation of bridges in the Netherlands

In order to explain what replacement- and renovation comprises of, it is needed to distinguish it from 'regular' maintenance. The main difference is the timing and nature of the works, or as Rijkswaterstaat (2022, p. 18) states: "the transition from the maintenance process to replacement- and renovation takes place when the end of the technical lifetime is reached", as is clarified in figure 6.1.

Figure 1.1; Three different measures for replacement- and renovation of fixed bridges (Rijkswaterstaat, 2022)
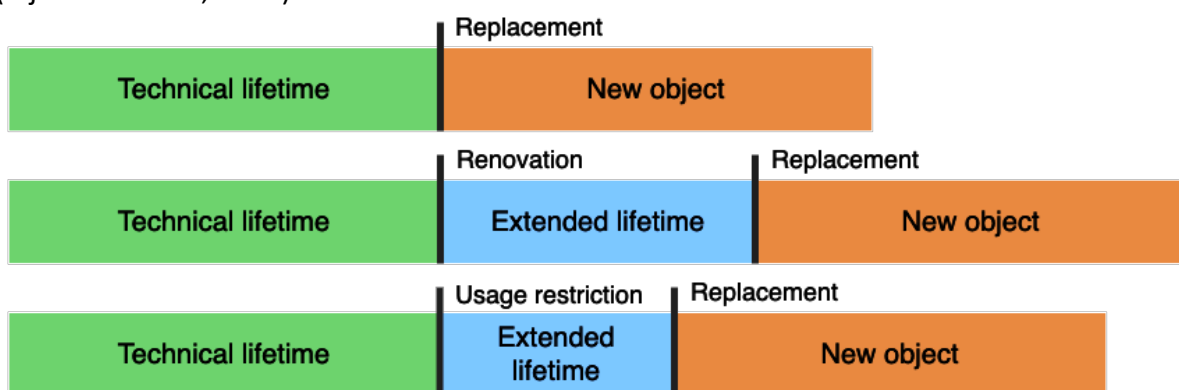
By reducing the usage of an object, its lifetime can sometimes be extended by for instance lowering the weight limit for a bridge or by closing a lane on a highway bridge. This is however an undesirable measure because not only does it postpone solving the problem, but when one bridge in a network of highways is used less, other bridges will likely be used more resulting in more extensive loads for other infrastructure which then needs to be renovated or replaced as well (van Belzen & Platschorre, 2024)*.*

This means that replacement- and renovation can be work that is not already included into the existing maintenance contracts. For fixed bridges such as viaducts (figure 1), sections of the object can be renovated, or the entire object can be replaced when it is assessed that the object has reached the end of its technical lifetime. If for some reason however the bridge cannot be renovated or replaced when needed, there is the non-favourable option of using restrictive measures to 'extend' an object's lifetime. One might say that a traffic diversion is not much of a problem, but diversions lead to higher loads on other old infrastructure, which results into new problems elsewhere. This shows how this problem is not just a sum of single objects, but a network of related projects (van Belzen & Platschorre, 2024).

For more complex bridges with moving parts, there is a difference to what replacement- and renovation comprises of in comparison to fixed objects (figure 2). It still relates to the technical lifetime, but the technical lifetime of mechanical parts or digital systems can be less than the technical lifetime of the fixed parts of the object. It is therefore necessary to replace or upgrade these mechanical or digital parts before the entire asset has reached the end of its technical lifetime.

Figure 1.2.: Renovation measures for replacement- and renovation of assets with complex systems (Rijkswaterstaat, 2022)
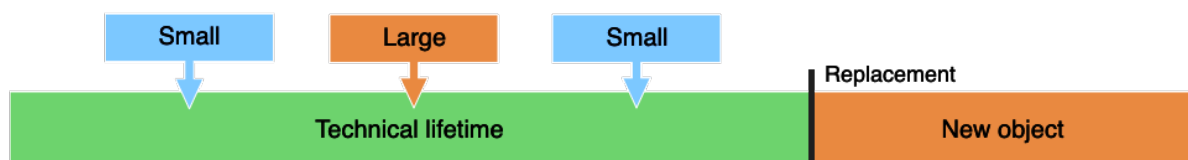
The small renovation activity shown here can consist of actions such as replacing or upgrading digital or mechanical systems, large activities can consist of renovating or replacing steal or concrete sections, and replacement- consists of the replacement- of the entire asset.

The 'end of technical lifetime' moment is however not as black and white as it may have been depicted in the images above and knowing when a bridge is not safe enough to use anymore is critical. Bridges can collapse in different ways, when they bend it can be noticed in time but with shear failures it is difficult to detect failure, as was the case with a bridge that collapsed in the city Lecco in Italy in 2016 (van Belzen & Platschorre, 2024).

1.2.   Bureau Herberekeningen: an inter-organisational recalculation programme for bridges

In order to find out what the current state and capacity of a bridge is, the load capacity of many of the critical bridges is recalculated with heavier modern traffic in mind. It is this increase in traffic loads that causes objects to reach the end of their technical life earlier than originally calculated (du Saar, 2024). For this reason, Rijkswaterstaat signed a framework agreement in February 2024 with 10 different Engineering firms for the recalculation of at least 250 steel, concrete, and movable bridges spread throughout the Netherlands (Rijkswaterstaat, 2023d). A more detailed description of this framework agreement and the 'bureau herberekeningen' ('bureau for recalculations' in English) is given in chapter 11.

The aim of the recalculation tender (Rijkswaterstaat, 2023d) is to simultaneously contract multiple engineering firms that, in close collaboration with Rijkswaterstaat, carry out constructive recalculations quickly and expertly to:

1. To determine the structural safety and residual lifespan of a multitude of bridges and viaducts,

2. To provide advice on (urgency of) measures in the short term (e.g. traffic restrictions, monitoring) and long term (Replacement or Renovation), and
3. To use and further develop, safeguard and share the limited available knowledge and expertise of Rijkswaterstaat and market parties with regard to recalculations as efficiently as possible.

It is the combination of bundling a large number of projects in a multi-year framework agreement and the project-transcending objective for better knowledge management that allows it to be compared with a programmatic approach for this research. It is not explicitly stated that this framework agreement is set up as a programme, but these aspects are what makes it interesting to consider the 'bureau herberekeningen' in this research.

At the time this research started (March 2023), the framework agreement had only been signed one month earlier. This meant that the work was still getting started and that a lot of the practical implications of the intentions of the bureau were still hypothetical at first. This research therefore presents findings as well as expectations about the framework agreement and the 'bureau herberekeningen'.

1.3. The challenge: knowledge management in an inter-organisational programmatic approach

The difficult part about the replacement- and renovation task is that it is a time sensitive challenge. If certain infrastructure needs to be closed because its use would not be safe anymore for modern traffic, it can have a large impact on society. In 2016 for example, the Merwede bridge was closed for trucks and lorries due to weight restrictions after hairline cracks were discovered, resulting in long diversions (TNO, 2023).

It is this time sensitive nature in combination with the size of the replacement- and renovation task that results in the necessity to work more efficiently and effectively. Part of the advice given by Rasker et al. (2023) is to "provide a perspective for action for the replacement- and renovation task by focusing on innovative working methods" by applying productivity-enhancing measures to do more with fewer resources. This includes scaling-up by using a programmatic and bundled approach, and through industrialisation of both replacement- and renovation. In order to benefit from this programmatic approach however, it is critical that projects are not just combined for the sake of combining but are combined to take advantage of the benefits of combining projects into a programme. This means combining experiences from different projects to know what works well and what doesn't work, learning from project to project, storing lessons learned, creating best practices, and sharing experiences. Lycett et al. (2004, p. 291) even argue that knowledge and information sharing between projects should be a cornerstone of effective programme management but "the aspect of 'knowledge transfer' has, for the most part, been neglected within the programme management discipline".

The struggle with learning from projects in construction now however is that projects, in this case renovation projects, are seen as temporary and unique (PMI, 2021), e.g., in scope, location, budget, timeframe, client, staff, technology, etc. This results in the need for knowledge management: the need to learn from one project to the next, because any learning that is accumulated in a project will now largely dissipate at the end of a project and priceless knowledge will be lost (Carrillo et al., 2004; Dave & Koskela, 2009; Egbu, 2004; Ferrada et al., 2016; Smith, 2001; Vignos, 2014; Williams, 2008; Zin & Egbu, 2009).The difficult part in the context of the renovation of infrastructure is when effective knowledge management becomes

more important. More challenges are then likely to arise because a lot is known, but not everything (van Belzen & Platschorre, 2024).

The challenge that thus follows is related to three subjects:
- A programmatic approach should be more beneficial than individual projects,
- The importance of knowledge management in the programmatic approach needs to be capitalised, and
- When an inter-organisational programmatic approach is organised, challenges in knowledge management will occur:
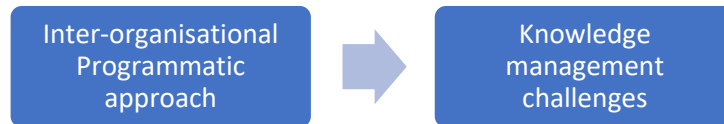
2. Research gap: practical challenges and solutions

Much has already been written about the programmatic approach and knowledge management, this research considers the combination of these two concepts in an inter-organisational setting. The combination of these two aspects is however becoming more important in the context of infrastructure renovation since the inter-organisational programmatic approach is now becoming more of an interest in the Netherlands (Rasker et al., 2023; Rijkswaterstaat, 2023d).

PMI (2017c) only includes information management and a lessons learned database into their standard for programme management, while ICT cannot be a knowledge management solution on its own (Carrillo et al., 2004; Dave & Koskela, 2009).

Nezami et al. (2024a) also identified 34 sub-criteria for inter-organisational collaboration in interconnected infrastructure projects from literature and then interviewed practitioners to compare these criteria with the answers given by the practitioners. Of the 34 identified criteria, 30 were mentioned in these interviews and among the criteria that were not mentioned was "encouraging the knowledge collection".

Li et al. (2022) also states that empirical studies of interorganisational in the context of programme management is scarce.

Because of this discrepancy between theory and practice, this research therefore tries to identify challenges in practice related to knowledge management and an inter-organisational programmatic approach in which public clients and multiple market parties collaborate.

3. Research aim: understanding challenges and solutions

Because of the research gap and the discrepancy mentioned earlier, the concepts 'programmatic approach' and 'knowledge management' are therefore central in this research substantiated by the collaboration and relations between different organisations within a programme. The aim of this research is to understand challenges and possible solutions related to knowledge management that might follow from an inter-organisational programmatic approach.

This research therefore tries to ***inform*** on what a programmatic approach can consist of, ***identify*** possible challenges related to knowledge management in an inter-organisational programmatic approach, and ***advice*** on overcoming these challenges when one uses a programmatic approach where knowledge management is a priority in practice. The target audience for this research are market parties such as engineering and consulting firms who might be involved in a renovation programme or who might be asked to advice on the use of a renovation programme.

4. Research questions

This research thus assumes that when multiple organisations, i.e. public clients and engineering firms, collaborate with the intent of using, developing, safeguarding and sharing knowledge between these parties, challenges will emerge. In order to assess this assumption and to fulfil the objective as described above, the main question for this research is:

How can we overcome challenges related to knowledge management in an inter-organisational programmatic approach for the replacement- and renovation task of bridges in the Netherlands?

In order to answer the main question and to comprehensive understanding, the following sub-questions are formulated:

1. *How should a replacement- and renovation programme be organised when there is a focus on knowledge management?*
2. *What are the most relevant challenges related to knowledge management when considering a replacement- and renovation programme?*
3. *How do the roles and assumptions in the information and knowledge landscape influence the challenges in a programmatic approach?*

The first sub-question is formulated to provide insight into how a programme theoretically should be organised. This can then present points of interest for identifying challenges when one for instance looks at project interfaces, current practices, and assumptions. This sub-question helps to answer the main question because it can describe the theoretical framework in which the challenges take place and what the reasoning behind a programmatic approach is. This sub-question also adds to the objective of informing on what a programmatic approach can consist of.

For the second sub-question, the goal is to get more insights into challenges related to the replacement- and renovation task in theory and in practice. This sub-question helps to answer the main question by identifying challenges that can occur and might need to be overcome.

The third sub-question is there to get an insight into how different parties might find different aspects of knowledge management important or relevant. Challenges may occur because certain parties might not assume the relevance of certain knowledge related activities or information similarly as other parties might. An owner might want to know different things or might have different priorities than an engineering company or a contractor. But also, when knowledge is shared between parties or when certain data is used, it is important to know where this data or knowledge came from and what the assumptions were before one should use it in their work.

5.   Research methodology: comparing theory and practice

In order to answer the research questions above and achieve the aim as described in chapter 3, the following research methodology was used. The research can be divided into two parts: a literature study and an empirical study.

Figure 5.1: Oversight of the steps taken in this research
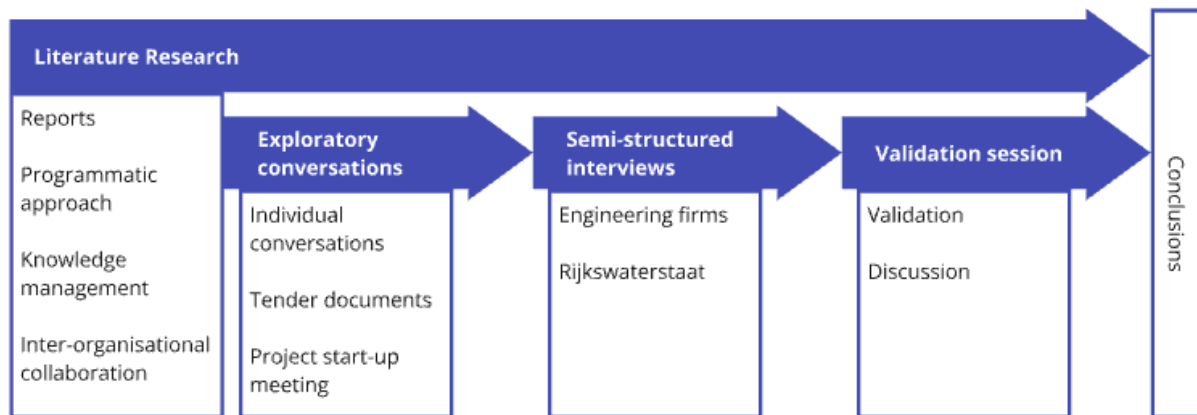
This figure gives an overview of the different steps taken in this research

The literature study mostly relates to the first research sub-question. In order to get a better understanding, the following three topics were chosen to be researched:
-   The programmatic approach
-   Knowledge management
-   Inter-organisational collaboration

These three subjects were compared to see which aspects are most relevant for the organisation of a renovation and renewal programme with a focus on knowledge management. The first two topics are self-evident. The third topic however was chosen because of the large number of engineering firms expected to collaborate in the 'bureau herberekeningen'.

This literature research then adds to the aim of informing, as described in chapter 3. This literature study also helped in forming the theoretical basis on which the empirical research is based.

The empirical research was conducted in collaboration with the Dutch engineering and consultancy firm Witteveen+Bos. They have been awarded a part of the recalculation framework agreement of Rijkswaterstaat for which they will have to recalculate at least 18 fixed steel- and 24 concrete bridges. They were also involved early on when there still were organisational decisions to be made by Rijkswaterstaat and can therefore also help getting in contact with people from other engineering firms and Rijkswaterstaat.

The empirical research is mostly related to the research sub-questions two and three. The empirical research will thus consider the framework agreement and the 'bureau herberekeningen' in order to answer the sub-questions and tries to identify challenges.

The first step for the empirical research was to get more familiar with what the framework agreement and the 'bureau herberekeningen' was comprised of. This was done through reading documents and having exploratory conversations, including being present at a large project start-up meeting.

The following step in the empirical research was conducting the semi-structured interviews. Using the theoretical basis of the literature study and the results from the exploratory conversations themes and questions were drawn up. The reason why semi-structured interviews were chosen is two folded. One the one hand, using structured interview allows for the answers to be compared more easily and allows for some sort of quantification of the answers. On the other hand, allowing for some flexibility in the conversation allows for the interviewee to introduce new topics that perhaps weren't identified when the questions were formulated. The semi-structured approach then allows to ask follow-up questions.

Finally, a validation and discussion session was organised. For this session, practitioners were invited and the results from the interviews were presented. These results were discussed in order to find out if they agreed with the results or if they had any additions or suggestions for alterations.

6. Structure of the report

This report consists of four sections, each subdivided in chapters, as can be seen in figure 6.1. Section I introduces this research and describes the context of the research, why it is done as it is, what questions it tries to answer, and how it tries to answer them.

Section II presents the literature research of the three themes: the programmatic approach, knowledge management, and inter-organisational collaboration. At the end of section II, an intermediate conclusion is given.

Section III considers the empirical research that was executed. First, a description of the framework agreement and 'bureau herberekeningen'. Then, the interview set-up, the results, and the validation session are presented. This section is also ended with an intermediate conclusion.

Section IV presents the final conclusions, including the discussion, recommendations for practitioners, and some suggestions for future research.

Figure 6.1: Sections and chapters of the report

Section I - Introduction	Section III - Empirical research
Ch.1 - Research scope and problem definition Ch.2 - Research gap Ch.3 - Research aim Ch.4 - Research questions Ch.5 - Research methodology Ch.6 - Report structure	Ch.10 - Description 'bureau herberekeningen' Ch.11 - Interview set-up Ch.12 - Interview results Ch.13 - Validation session Ch. 14 - Conclusions for the empirical research
Section II - Literature research	Section IV - Conclusions
Ch.7 - Programmatic approach Ch.8 - Knowledge management Ch.9 - Inter-organisational collaboration Ch. 10 - Conclusions from the literature	Ch.15 - Discussion Ch.16 - Conclusion Ch.17 - Recommendations Ch.18 - Suggestions for future research

II.   Literature study

As described in the introduction, a literature study was conducted to get a better understanding of the theoretical context of this research. The following three subjects were chosen to be considered:

1. The programmatic approach   Chapter 7
2. Knowledge management   Chapter 8
3. Inter-organisational collaboration   Chapter 9

In chapter 10, an intermediate conclusion is given of the literature study.

This chapter tries to identify what these topics entail and what the interfaces between these different topics are in order to find answers for the following sub-questions:

1. *How should a replacement- and renovation programme be organised when there is a focus on knowledge management?*
2. *What are the most relevant challenges related to knowledge management when considering a replacement- and renovation programme?*

Figure II.1: Prins Clausplein

Part of the concrete bridges that have been identified by Rijkswaterstaat to be recalculated are the viaducts of the Prins Clausplein near The Hague in the Netherlands. Photo: Wolfgang Pehlemann

7. Programmatic approach

This chapter gives the results of the literature research related to the topic 'programmatic approach'. This chapter tries to provide a better understanding of the theories and literature available relate to the general research aim and questions.

This chapter considers two subjects:
- What a program consists of and
- What conditions are necessary for a successful program

The papers and books used for this chapter were mainly retrieved form Google Scholar where the keywords such as 'programme management', 'programme management in construction', and 'infrastructure programme management' were searched. Other sources were found through the references provided in other papers.

7.1. Combining projects to obtain project-transcending objectives

A programme is defined as a combination of related projects or subsidiary programs that are combined in order to achieve benefits that would not be realised if these projects were managed independently (Lycett et al., 2004; Maylor et al., 2006; Pellegrinelli et al., 2014; PMI, 2017; Rijke et al., 2014). "Programs are conducted primarily to deliver benefits to the sponsor organisations or constituents of the sponsoring organisation" (PMI, 2017a, p. 3).

Figure 7.1 shows how these subsidiary programs and projects can be organised. Figure 7.2 shows how projects and programs can be organised through time: sequential, in parallel, or as a network (Lycett et al., 2004; Maylor et al., 2006).

Figure 7.1: Organisation example for projects, portfolios and programs
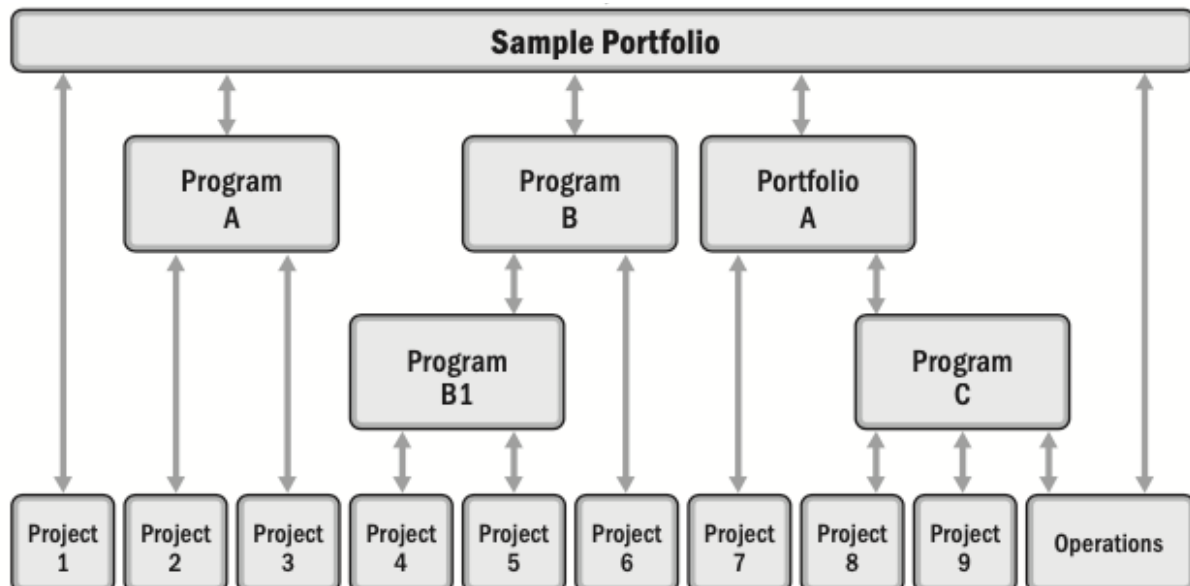
This figure shows an example of how projects and programs can be organised in relation to each other (PMI, 2017a)*. A project and a programme can thus both contain multiple projects or subsidiary programs or portfolios, but the difference is that programs aim to realise a benefit that is not directly linked to the scope of its projects.*

Figure 7.2: Order of projects in a program
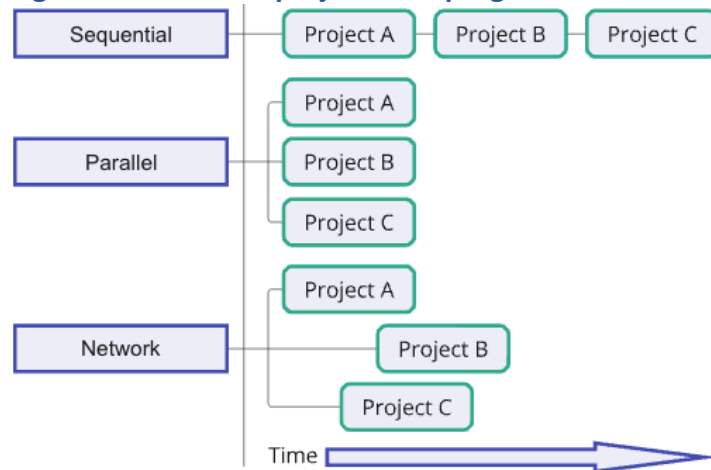
This figure shows how the individual projects can be organised relevant to each other through time. Because a programme consists of multiple projects it is more likely to be a long-term endeavour (Maylor et al., 2006)*.*

Because programs aim to deliver benefits that cannot be delivered by individual projects, programs also include elements that are not directly included into the scope of the individual projects (Lycett et al., 2004; Maylor et al., 2006). Projects typically focus on tactical performance, such as time, cost, and quality requirements, while programs adopt a more holistic perspective on goals and benefits. These benefits for example include "enhancing current capabilities, facilitating change, creating or maintaining assets, offering new products and services, or developing new opportunities to generate or preserve value" (PMI, 2017a). Also, "programs introduce change throughout their duration. This change may be reflected with the introduction of a new product, service, or organisational capability" (PMI, 2017b). Programmes deliver benefits through better organisation of projects, but do not deliver individual project objectives (Lycett et al., 2004). It is this notion that a programme must achieve a project-transcending goal or create benefits that cannot be achieved by individual projects that sets it apart from a portfolio (Lycett et al., 2004). Portfolios also consist of combining projects but do not include a project-transcending objective, other than combining projects out of convenience. PMI (2017b) also adds to his that projects in a program should be combined because they 'relate', whereas projects in a portfolio can be entirely independent and not related.

Programme management is then needed to achieve the goals and obtain the benefits from a programme. Programme management consist of the "application of knowledge, skills, and principles" and "the alignment of programme components to ensure that program goals are achieved, and program benefits are optimally delivered" (PMI, 2017a).
Rijke et al. (2014) identified three forms of programme management:
- Portfolio style management,
- shared service centre, and
- Goal-oriented programme management

'Portfolio style management' consists of a higher-level fine-tuning of project goals, while maintaining the planning and budget cycles of individual projects.

As a 'service centre', programme management coordinates expertise among different projects by integrating for instance financial, legal, administrative, and technical services.

'Goal-oriented programme management' considers the programme goals to be more dominant and considers these to be more important than the objectives of individual projects. This then results in prioritisation and adjustments to be determined centrally in order to achieve the project-transcending objectives.

Rijke et al. (2014) add though that programme management in practice will likely consist of a combination of classifications.

Finally, a reoccurring challenge for every organisation is to utilise the knowledge that is already there, as well as having enough resources in the meantime to innovate and ensure success for the future (Pellegrinelli et al., 2014). Using the language of ambidexterity (Havermans et al., 2015), project management and projects are more appropriate for exploitation, and program management and programs for exploration. Exploitation here then entails using the existing knowledge efficient and fast. Exploration on the other hand means that there is the desire and room for innovation and experimentation to go beyond the status quo(Pellegrinelli et al., 2014).

7.2.   Conditions for programme success

PMI (2017b) provides five program Management Performance Domains that are critical for programme success:

1. **Program Strategy Alignment**; programme outputs and outcomes are identified here to provide the benefits aligned with the organisation's goals and objectives.
2. **Program Benefits Management**; comprises the definition, creation, maximisation, and delivery of the benefits delivered by the programme.
3. **Program Stakeholder Engagement**; is about identifying and analysing stakeholder needs. Communication and involvement are especially important here in order maintain stakeholder support.
4. **Program Governance**; outlines and executes decision-making, implements practices to support the program, and ensures ongoing program oversight.
5. **Program Life Cycle Management**; oversees program activities necessary to ensure effective program definition, delivery, and closure.

A programme probably involves a significant change and potentially across multiple organisations. Clearly defined goals and objectives will ensure that there is a good understanding of what needs to be delivered to achieve the desired outcomes (Shehu & Akintoye, 2009). From there on out, it is crucial to "retain an explicit, frequently revisited focus on the intended benefits of the programme to remain on track and achieve the desired outcome" (Shehu & Akintoye, 2009, p. 5).

PMI (2017d) suggests a benefit register to collect and list planned benefits for the programme. This register can then be used to communicate and measure if and how the benefits are being realised. Key performance indicators can then be included here along with their associated quantitative- and qualitative measures as well as the stakeholders.

Regarding stakeholder engagement, Rijke et al. (2014, p. 1199) state that internal stakeholder collaboration is important to align objectives, roles, and responsibilities in order to "formalise the ideation strategically in a way that a broadly supported programme vision is developed with overarching programme goals, and a programme priority focus that allocates resources

to these goals". Understanding the stakeholders related to the programme is crucial to understand their attitude towards the program (Shehu & Akintoye, 2009).

Programme governance should be perceived as contextual. Appropriate programme processes, structure, and organisation should be dependent on factors such as the degree of interrelation among the projects, the characteristics of the individual projects, and the nature of the organisations involved (Lycett et al., 2004). The role of a programme management office can be key, because it enables the organisation of programme governance, coordination, and adaptation (Rijke et al., 2014). Adaptation is important here due to the relative long-term duration of a programme; it is likely there can be contextual changes. This thus needs to be implemented in the organisational strategies, the flexibility of programme structures and procedures.

When one considers adaptation of a programme due to changes in the organisational context outside of the programme, the concept of double loop learning becomes relevant (Argyris, 1977). This entails that there is not only a learning loop that checks if the programme is delivering what was intended but also if that what was intended still fits with the programme's organisational context.

Comparing the programmes to projects, Pellegrinelli et al. (2014) differentiates that programmes should be coordinating frameworks that offer flexibility, accommodation, and the realisation of the benefits. Projects on the other hand should offer focus, control, and effectiveness of delivery. It can still be expected that the projects have to deliver on time, on budget, within scope, and with a certain quality. For program activities though, it should be required that they contribute to the program goals and benefits (PMI, 2017b).

Programme management must thus enable the adjustment of specific project deliverables to ensure that each project coherently contributes to the achievement of the overall program goals and benefits throughout the entire programme life cycle (Lycett et al., 2004). If an organisation does not have much experience with programmes, it must plan time to allow for development and learning (Shehu & Akintoye, 2009). This organisation should then map out this learning and development of requirements throughout the programme life cycle. They should continuously learn from their practices and adopt changes where necessary.

8. Knowledge management

Because of the importance of knowledge transfer in a programmatic approach (Lycett et al., 2004), it is needed to get a better understanding of the theories already available in literature. This research however tries to look beyond knowledge transfer and considers knowledge management.

The papers and books used for this chapter were mainly retrieved form Google Scholar where the keywords 'lessons learned', 'lessons learned in construction', knowledge management', 'knowledge management in construction', and ' tacit knowledge' were searched. Other sources were found through the references provided in other papers. Some sources, such as (PMI, 2021) were retrieved from webpages.

Before looking further into what knowledge management is, it is first necessary to consider what knowledge is. For knowledge however, this can be quite challenging due to its abstract and ambiguous nature. Here, the definition of knowledge as used in this research is given:

__Knowledge__ is the __relevantly useable interpretation of information by an individual or organisation__ and includes observations meaningfully formed and gathered from __experience__, communication, or by conclusions. Knowledge is __context dependent and dynamic__ because it arises from interactions and can change over time. Within an organisation, knowledge can however be seen as an asset or possession with a value (Andriessen, 2004; CEN, 2004a; Egbu, 2004; Grundstein, 2008, 2013; Nonaka & von Krogh, 2009)

Some define knowledge as a scientific truth that exists independently of human actions, while others believe it is socially constructed (Egbu, 2004; Grundstein, 2008). This research, aligning with Nonaka & von Krogh (2009), views knowledge as a dynamic human process.
From the definition above, a key aspect is that knowledge must be 'relevantly usable'. These two words distinguish knowledge from mere information. For example, a bread recipe is valuable knowledge for a baker but irrelevant information for engineers (unless they enjoy baking). Calling something irrelevant knowledge is thus a 'contradictio in terminis'.
The phrase 'interpretation by an individual or organisation' underscores knowledge as a human process (CEN, 2004a). Further elaborated in sub-chapter 3.1.2, it is the experiences and prior knowledge of individuals or organisations that determine whether something is relevant knowledge or just information (Grundstein, 2013). Andriessen (2004) describes organisational knowledge as what remains when the staff leaves for the day, emphasising that although it is an asset to an organisation, knowledge is not an object but is inherently linked to individuals (Grundstein, 2013).

Within the concept of knowledge, it is necessary to make a distinction between Implicit- (Tacit-) and Explicit knowledge.

__Implicit- or Tacit knowledge__ is a hidden form of individual knowledge that __'sits in the head'__ and is __difficult or sometimes impossible to transfer__, depending on where on the __implicit-explicit spectrum__ it is. Implicit knowledge is __inescapable__ and includes __experiences, skills, intuition__, and social interactions (Ambrosini & Bowman, 2001; Nonaka & von Krogh, 2009).

Polanyi was the first to describe the concept of tacit knowledge, defining it as "the fact that we can know more than we can tell" (Ambrosini & Bowman, 2001, p. 812). This explains why

tacit knowledge is often internalised and challenging, if not impossible, to transfer. Although Polanyi originally asserted that tacit knowledge cannot be transferred by definition, this research operates on the premise that tacit knowledge can indeed be transferred by converting it into explicit knowledge. This is based on the tacit/explicit continuum of knowledge (Nonaka & von Krogh, 2009), which ranges from deeply ingrained tacit knowledge to tacit knowledge that can be imperfectly or fully articulated, and finally to explicit knowledge (Ambrosini & Bowman, 2001). Tacit knowledge encompasses experiences, skills, and intuition, with skills being an equivalent to 'know-how': the practical knowledge of how to perform tasks (Ambrosini & Bowman, 2001).

Explicit knowledge is easily transferable, easily usable, recorded or written down knowledge. This is knowledge that the owner is aware of, and this knowledge can be articulated or described well (Grundstein, 2008; Smith, 2001).

Because explicit knowledge is written down and codified in formal language such as manuals, reports, or documents, and can thus be transferred easily (Smith, 2001). It can also be saved easily, making it less likely to get lost. Grundstein, (2008, p. 417) even goes as far as saying that "formalised and codified knowledge is nothing more than information". This research would not go this far though because of the stipulation that knowledge is relevant information. It is thus this difference in relevance that differentiates explicit knowledge from information.

8.1. Identifying, storing, retrieving, sharing, and using knowledge

Knowledge management is a systematic approach to identifying, storing, retrieving, sharing, and using knowledge and information with the necessary processes, systems, roles, and culture. Knowledge management should ensure that the tacit and explicit knowledge within an organisation is utilised and shared to be linked to the potential of individual skills, competencies, thoughts, innovations, and ideas to create a more efficient and effective organisation (CEN, 2004b, 2004a; ODI, 2009).

Figure 8.1: Explanatory schematic of knowledge management
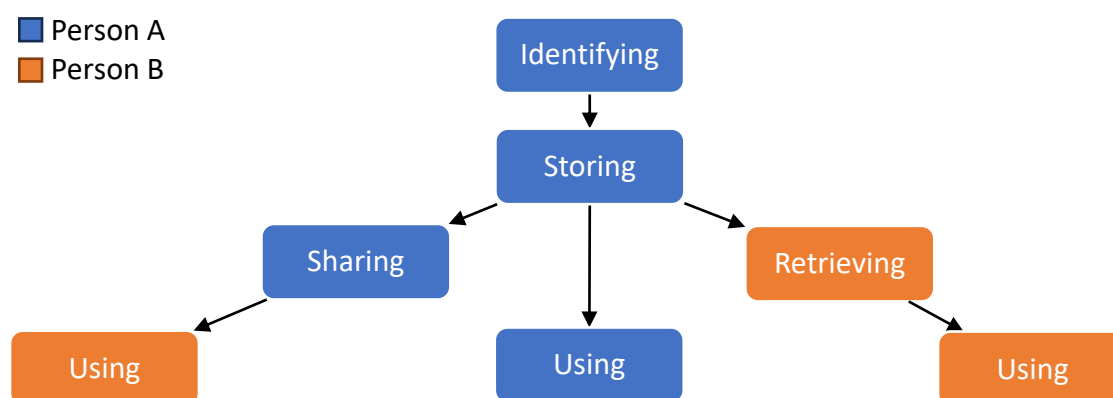
This figure illustrates roughly how the five components of knowledge management relate and how the course of knowledge and information can be interpreted. There are still some variations of this schematic to be imagined that fit within the definition as given above. This schematic is formulated with the view of person A in mind. One could though argue that when this schematic is considered from the view of person B, retrieving could also be intertwined with identifying.

From the European guide (CEN, 2004a), the five components of knowledge management were composed with the difference that 'retrieving' is given here instead of creating. This was decided here because of the notion that retrieving more neatly encompasses the idea that one tries to search for the knowledge needed when a problem or situation occurs. The reason why creation is not explicitly used here is because it is assumed to be the result of identifying relevance of experiences or information. Thus, new knowledge can be created but is imbedded here into the component of identification.

'Identifying' here thus means that it is identified if information or lessons-leaned from an experience are relevant. Activities such as project evaluations are carried out in order to identify relevant lessons learned. It can then help if there is a clear understanding of the knowledge that is already stored, in order to then identify if lessons learned or information arising from projects are relevant for the future.

'Storing' entails that knowledge is saved for future use. This can either be by individuals remembering or knowing something, but it can also be stored explicitly and codified in for instance a database. Either should be with the goal of preventing knowledge from getting lost. It is of course impossible to store all the knowledge of every individual within an organisation, but knowledge storage can decrease the loss of useful knowledge (ODI, 2009).

'Retrieving' is about the possibility for individuals to easily find relevant knowledge or information. This can either be done by getting access to codified knowledge in for example a database or by finding someone that knows what they need to know and then take that information or knowledge with them. The difference with identifying here is that a person actively searches for relevant knowledge.

'Sharing' is about individuals actively sharing knowledge and information, either codified or verbally.

'Using' is about individuals taking the knowledge using it in their work. Knowledge can only add value when it's used, but a lot of knowledge remains under-utilised, so this activity is about making sure that all effort that is spent in the previous activities pays off (CEN, 2004a).

The processes referred to in the definition include activities such as project evaluations or kick-off meetings. The systems encompass tools like databases or intranet platforms. Roles pertain to the responsibilities that staff members hold in relation to knowledge management. Culture, on the other hand, describes the way an organisation operates and behaves, i.e. 'the way we do things around (CEN, 2004b).

8.2.   Models used to explain knowledge sharing
In order to create a theoretical basis for knowledge management as described before, two different models are considered here: the SECI model by Nonaka (1994), and the ITEK model that is created by Grundstein (2013). These models both consider how knowledge is shared between individuals, but they do have slight differences. The models are compared and considered for combination at the end of this sub-chapter.

Figure 8.2: The SECI model
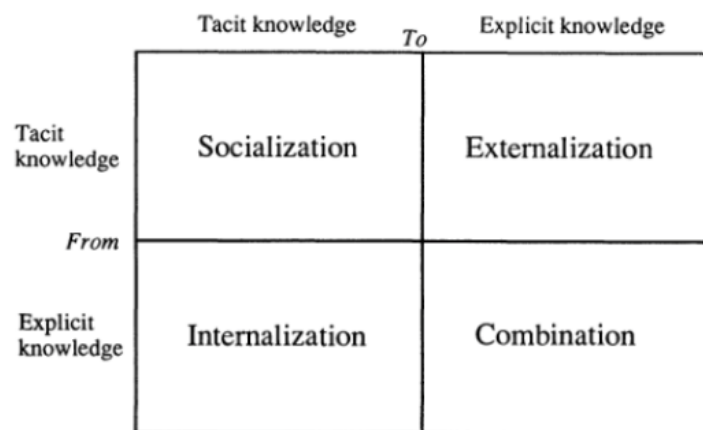
the SECI model consists of four conversions between tacit- and explicit knowledge: socialisation, externalisation, combination, and internalisation. The input of the matrix is on the left and the output is at the top (Nonaka, 1994).

The SECI model that is shown above shows four conversions between tacit- and explicit knowledge: socialisation, externalisation, internalisation, and combination. The reason why this model is considered here as a foundation for a knowledge management is that this model considers both tacit- and explicit knowledge and substantiates that they are convertible. This allows for the identification, storage, retrieval, sharing and usage of knowledge to be substantiated for tacit- and explicit knowledge:

- Socialisation can be linked to identification and sharing.
- Externalisation can be linked to identification, sharing, and storing.
- Combination can be linked to storing and using.
- Internalisation can be linked to retrieval and using.

'Socialisation' allows for the conversion of tacit knowledge through interaction between individuals. This can be either through language, but also by observation, i.e., learning by watching someone do something. This is also where for example mentoring and on-the-job learning subside.

'Externalisation' can be described as the process of expressing tacit knowledge through language, including explaining something in written form. Given the idea that knowledge exists on a spectrum from tacit to explicit, externalisation reduces the 'tacitness' of knowledge. Nonaka & von Krogh (2009) argue however that not all tacit knowledge can be fully captured in language, drawings, models, or manuals: "The theory should not reduce all tacit knowledge to that which can be potentially articulated."

Techniques like 'causal mapping' (Ambrosini & Bowman, 2001) or the 'five whys' method (Gangidi, 2019) can be used to externalise tacit knowledge. Both these methods involve repeatedly asking the respondent to reflect on a situation to uncover the root cause. Ambrosini & Bowman (2001) note that responses such as "oh yes, that's right", "Aha", or "I hadn't realised that" can indicate that tacit knowledge is being made explicit.

'Combination' comprises the reconfiguration of existing explicit knowledge or information through sorting, adding, recategorizing, and recontextualising. This entails for instance bundling drawings into a report or assembling documents into a digital database in a meaningful manner.

'Internalisation' is about the conversion of explicit knowledge or information into tacit knowledge and can somewhat be compared to the traditional notion of 'learning'. This can either be by reading text such as manuals but can also be through 'learning by doing'. The latter is though more relevant to 'know-how' and not only to 'know-what'.

Figure 8.3: The ITEK model
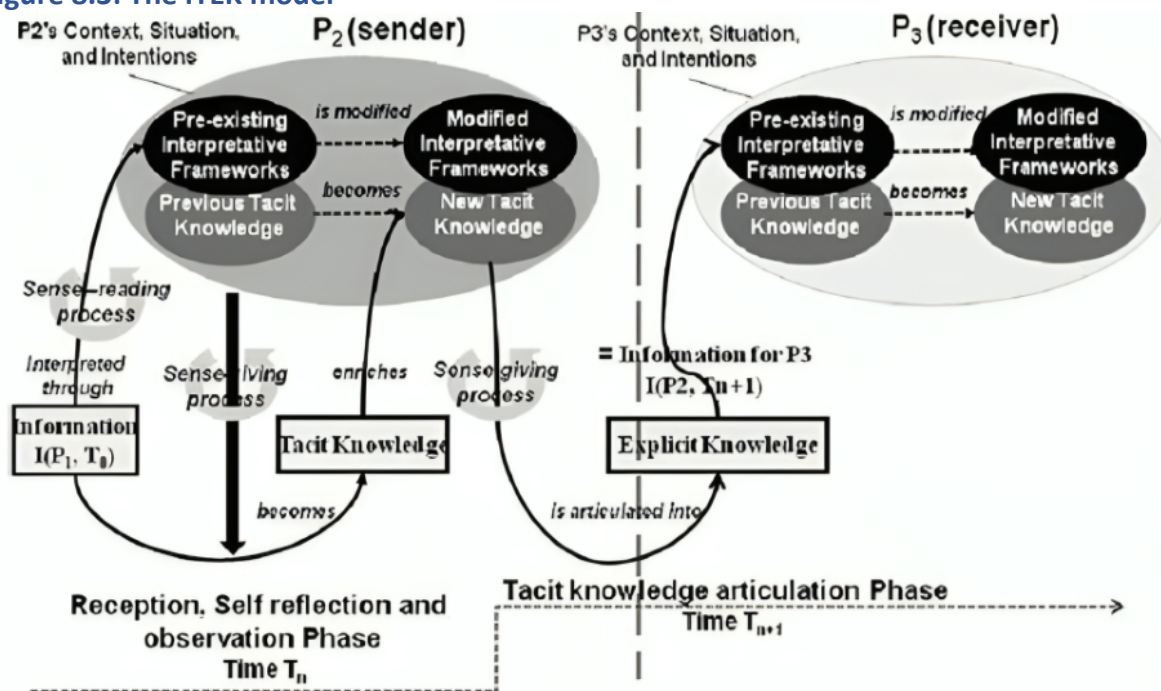
The ITEK model displays how one internalises and externalises information and knowledge. It introduces the 'pre-existing interpretative framework' that consists of previous tacit knowledge, including experiences and educations. This framework determines how one interprets information and what determines if information turns into knowledge. This model is a second part of another model that explains how data is converted into information, but which is not implemented in this research. It is therefore called the ITEK model here instead of DITEK, as it was originally called by .

The ITEK model considers the relationship between information, tacit-, and explicit knowledge and shows how knowledge is related to interpretation (Grundstein, 2008). Figure 8.3 visualises on the left half how an individual interprets information by making sense of that information through the 'sense-reading process' based on that individual's pre-existing interpretative framework and previous tacit knowledge and then internalises that information by converting it into tacit knowledge through the 'sense-giving process'. Sense-reading can thus be seen as the filter that assesses if information is relevant and the sense-giving process is how the information is internalised to understand it.

On the right half, figure 8.3 shows the sharing of knowledge between two individuals. First, the sender externalises their tacit knowledge by articulating it into explicit knowledge. As mentioned earlier, Grundstein (2008) states that codified knowledge and thus in some cases

also explicit knowledge can be equated to information, of which the receiver will then try to make sense based on their pre-existing interpretative framework.

The introduction of this 'interpretative framework', consisting of previous tacit knowledge, experiences, and education, is what makes this model interesting when assessing knowledge management. First, it is this framework that determines relevance of information and thus determines if something is useful knowledge or not. Polanyi (1967, p. 88) states that "when information is sense-read through interpretative framework, it becomes knowledge". It then follows that because the interpretative framework is linked to an individual, relevance can become subjective. This means that different individuals interpret certain information differently.

Secondly, this framework also can be seen as the reason why certain tacit knowledge can be shared through socialisation. If two individuals have similarity or commensurability in their interpretative framework, i.e., by having enjoyed similar education, similar experiences, or having the same profession, then one can consider it as sharing knowledge instead of sharing information (Grundstein, 2013).

Figure 8.4: Projecting the SECI model on the ITEK model
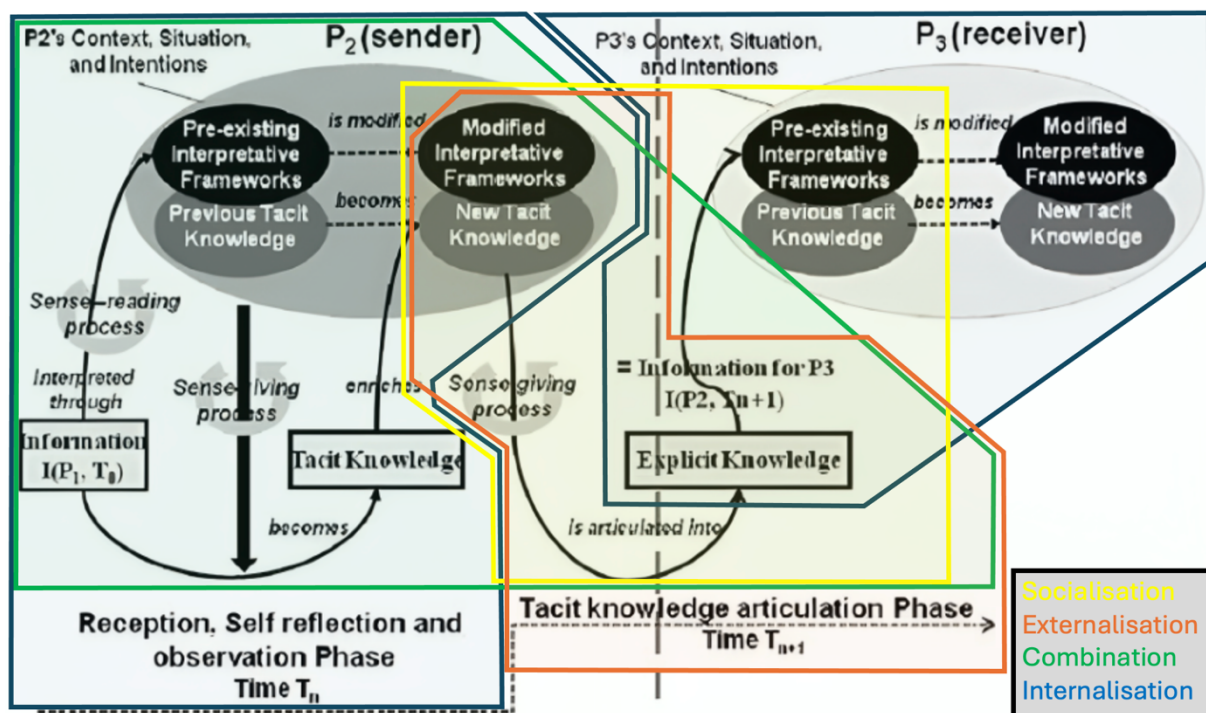
This figure takes the ITEK model (Grundstein, 2013) and projects the SECI model (Nonaka, 1994) on top. The two blue shapes represent the internalisation of explicit knowledge into tacit knowledge. The green shape represents the combination of explicit knowledge. The orange shape here represents the externalisation of tacit knowledge. Socialisation is represented here as the yellow box. In the ITEK model all knowledge shared is explicit. When considering the SECI model however, tacit knowledge can be shared as well by learning through observation for instance. The yellow box here thus does include the articulation of tacit knowledge, but this is not a requirement.

There are a number of points to note though when one starts to compare or even combine the ITEK and the SECI models. First, the SECI model is more of a general model for the conversion of tacit and explicit knowledge. The ITEK model however considers this conversion

as well but places it more in the context of individual people and how they theoretically share knowledge.

Secondly, there is an underlying difference in the assumption for the possibility to share explicit knowledge made by Grundstein (2013) and by Nonaka (1994). Grundstein states that all explicit knowledge shared between individuals is nothing more than information for the receiver (figure 8.3). Nonaka though states that explicit knowledge can be shared and differentiates it from information. This research is more in line with the thinking of Nonaka, because of the definition of knowledge given at the beginning of this chapter. Due to the notion that knowledge is relevant information, it can be argued that the difference between knowledge and information is relevance. One could then argue that for example written text can be explicit knowledge too as long as it is relevant to the reader. So, it can be argued that explicit knowledge can be shared because certain information can be considered explicit knowledge. But it also goes the other way around; some explicit knowledge can be considered irrelevant information to others. It thus depends on the interpretation of the receiver and what they consider to be relevant.

When one combines the two different models though, they also can complement each other. Where the SECI model describes what the four different types of knowledge conversion are, the ITEK model can then describe how these conversions take place and what the necessary conditions are.

Considering figure 8.4 for instance, the four differently coloured shapes project the SECI model onto the ITEK model. Taking socialisation, tacit knowledge is being shared between two individuals. This can either be done through articulation and externalisation or trough learning by observing. This would then even exclude the articulation step. The only thing that might be added in figure 8.4 is that more of an exchange takes place with socialisation instead of just a one-sided contribution. Nonaka (1994, p. 19) also states about socialisation that "without some form of shared experience, it is extremely difficult for people to share each other's thinking processes". This statement is in line with the notion from Grundstein (2013) of the commensurability of the interpretative frameworks of two individuals. A high commensurability or similarity of the pre-existing interpretative framework is thus a requisite for sharing tacit knowledge through socialisation.

For externalisation, figure 8.4 shows how the tacit knowledge within an individual can be converted into explicit knowledge or information through articulation and the sense-giving process. This model also gives a reason why different people can externalise and explain similar knowledge differently; due to a difference in the pre-existing interpretative framework. This results in a different sense-giving process resulting in different explicit knowledge.

Combination is projected onto the ITEK model in figure 8.4 with the reasoning that an individual takes information or explicit knowledge and transforms this into new explicit knowledge or information. The ITEK model here thus shows how an individual can for instance recontextualise information through sense-reading, comparing it to and with their pre-existing interpretative framework, to then convert it into new explicit knowledge through the sense-giving process.

Internalisation is shown twice in figure 8.4 due how the ITEK model is presented. It still shows how an individual can receive information or explicit knowledge and through the processes of sense-reading and sense-giving turn this into new tacit knowledge. Similar as with externalisation, this model again explains that due to a difference in the pre-existing interpretative frameworks of different individuals' information can be internalised and interpreted differently by different people

8.3.   The dichotomy of knowledge into codified- and social knowledge management

There is a need for a two folded approach that focusses both on codified knowledge management and on social knowledge management. The figure below shows how this can be substantiated by the SECI model.

Figure 8.5: The dichotomy of knowledge management
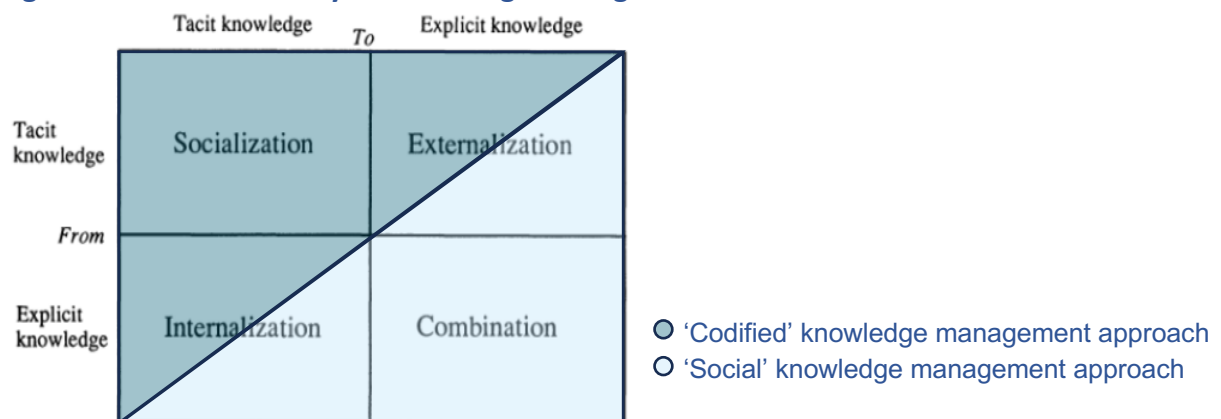
A representation of how the dichotomy of knowledge management relates to the SECI model with the social- and codified knowledge management. This also shows that to include all aspects of knowledge conversion and thus include all aspects of knowledge management both a codified approach and a social approach is necessary. Adapted from the model of Nonaka *(1994).*

On the one hand, because codified knowledge and information are easier to store and decrease the chance of 'forgetting' something, an IT based solution is an important part of knowledge management. These IT based tools such as apps, databases, intranet, and digital forms are vital for easy acquisition, storage, and sharing of information and explicit knowledge. They are thus necessary for knowledge management success (CEN, 2004a; Egbu, 2004; Eken et al., 2020; Smith, 2001; Zin & Egbu, 2009). There is however an understanding that most of the problems related to ICT are associated with its implementation and that ICT is a facilitator for knowledge management. An ICT system cannot be a knowledge management solution on its own (Carrillo et al., 2004; Dave & Koskela, 2009).

Knowledge, and especially tacit knowledge, is connected to individuals and interaction and an approach focussed on social interactions is needed as well. Socialisation is therefore only obtainable through social inter-people interactions. Smith (2001, p. 317) mentions on this subject that "IT does not provide content. People do." Knowledge management can therefore never only be about IT and must involve people, communication, and human interaction (Nonaka & von Krogh, 2009; H. S. Robinson et al., 2004; Zin & Egbu, 2009).

Taking it even a step further and combining the SECI-, the ITEK model, and the codified-social dichotomy, the following examples can be given to show how they can be combined:

- Sharing and discussing insights on methodologies between two experienced professionals is an example of socialisation through sense-reading and sense-giving.
- Presenting project results is social externalisation through sense-giving.
- Writing a report is an example of codified externalisation through sense-giving,
- Reading reports to identify lessons learned and writing a new best practice document is a form of combination through sense-reading and sense-giving.
- Listening to a presentation and remembering what was said is a form of social internalisation through sense-reading.
- Reading an article and remembering what it was about is a form of codified internalisation through sense-reading.

9. Inter-organisational collaboration

Because of the large number of engineering firms expected to collaborate in the 'bureau herberekeningen, the topic of 'inter-organisational collaboration' was included into this literature research as well.

The papers and books used for this chapter were mainly retrieved form Google Scholar where the keywords such as 'inter-organisational collaboration', 'inter-organisational collaboration in construction' and 'network governance' were searched. Other sources were found through the references provided in other papers.

For collaboration, the four characterisations Nezami et al. (2022, pp. 2–3) identified are used:
1. Collaboration engages organisations and interested individuals with a stake in the outcomes.
2. Collaboration requires a commitment of parties to solve problems.
3. Collaboration involves participants in an intensive and creative process, resulting in creative solutions which increase the possibility of acceptance.
4. Collaboration contributes to achieving a consensus on issues, aims, and proposed actions.
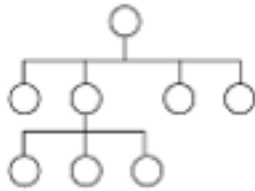
When the context of a project or programme requires multiple parties to be involved closely, inter-organisational becomes relevant. Collaboration when different organisations are involved in a project is crucial for project success (Dietrich et al., 2010) and it can help organisations solve problems they cannot tackle alone (Butcher et al., 2019). This allows the collaboration to deliver outcomes that benefit all parties involved. Issues such as insufficient close collaboration, poor communication, and low participation from organisations involved are however identified commonly (Nezami et al., 2024b).

9.1. Network governance

Collaboration can be organised in various ways, of which three are shown in table below. In practice, organisations can use a mix of these governance modes, and the importance of a certain governance mode can even change according to the maturity of the network and the tasks undertaken (Keast & Hampson, 2007). The network governance is most relevant though in the context of this research because one could argue that a program is also a network of projects.

Table 9.1: Three different modes of governance

Governance mode	Market	Hierarchy	Network
Visualisation			
Principles	Exchange relationship Formalised, contractual, and legal arrangements Transactions, bargaining Contractual management	Authoritarian Centralised authority, rules, regulations and procedures Administrative management	Social relationships Interpersonal trust, mutuality and reciprocity Relational management

This table shortly describes and visualises three different modes of governance: market-, hierarchy-, and network governance (Keast & Hampson, 2007a; Kenis & Provan, 2008a)*.*

9.2. Relations in Networks and programmes

Keast & Hampson (2007, p. 371) state that relationships "are an important aspect of networks", and that "they must be strategically managed to secure optimal outcomes". Lycett et al. (2004) also state similarly that effective programmes are also based on relationships. They state that an important aspect of programme management is to facilitate effective relations between the people working on the different projects within the programme to "ensure that they work together effectively and remain collectively focused on the achievement of overall benefit" (Lycett et al., 2004, p.297). Proximity, or being near on another, of the people working on the projects within a program also influences the collaboration (Li et al., 2022).

Li et al. (2022) also state that financial gains should not be the driving force to form inter-organisational relationships but that the long-term and relational aspects drive the formation of network relationships. Within a relationship, trust is an important aspect as well. Trust can allow for a less hierarchical form of relationships (Li et al., 2022). If organisations operate within a relationship with real collaboration to achieve a shared objective or mutual goal, then this relationship will be characterised by trust and commitment (Dietrich et al., 2010).

For programs, Lycett et al. (2004) mentions three important relationships:
- The relationship between the programme manager and the subsidiary project managers,
- The relationship between the programme and the organisational strategy, and
- The relationships between the individual projects.

They add here that all of the challenges when programme management is used can be related to the inefficient management of one or more of these relationships.

For the first relationship, they mention that a challenge here is the tendency to "obtain an inappropriate level of detail driven by a desire to exercise an inappropriate degree of control". This then results in two negative consequences: "excessive hierarchical bureaucracy and control and focus on an inappropriate level of detail" (Lycett et al., 2004, p. 293).

For the second relationship, they mention that it is important align the programme with the evolving business environment. Programmes should be kept flexible to ensure a positive relationship with the organisational strategy and wider business context.

For the third relationship, it is mentioned that difficulties at the interfaces between projects should not be ignored. Rivalry between projects can lead to two negative consequences: "inter-project competition and failure to harness organisational learning". "In an environment of intense competition, projects operate so autonomously that they simply do not know what people outside their own team are working on" (Lycett et al., 2004, p. 294).

10. Combining literature into a theoretical framework

Following the previous chapters and the literature research, this chapter suggests a theoretical framework. This framework tries to combine the three topics discussed: the programmatic approach, knowledge management, and inter-organisational collaboration.

Figure 10.1: Theoretical framework
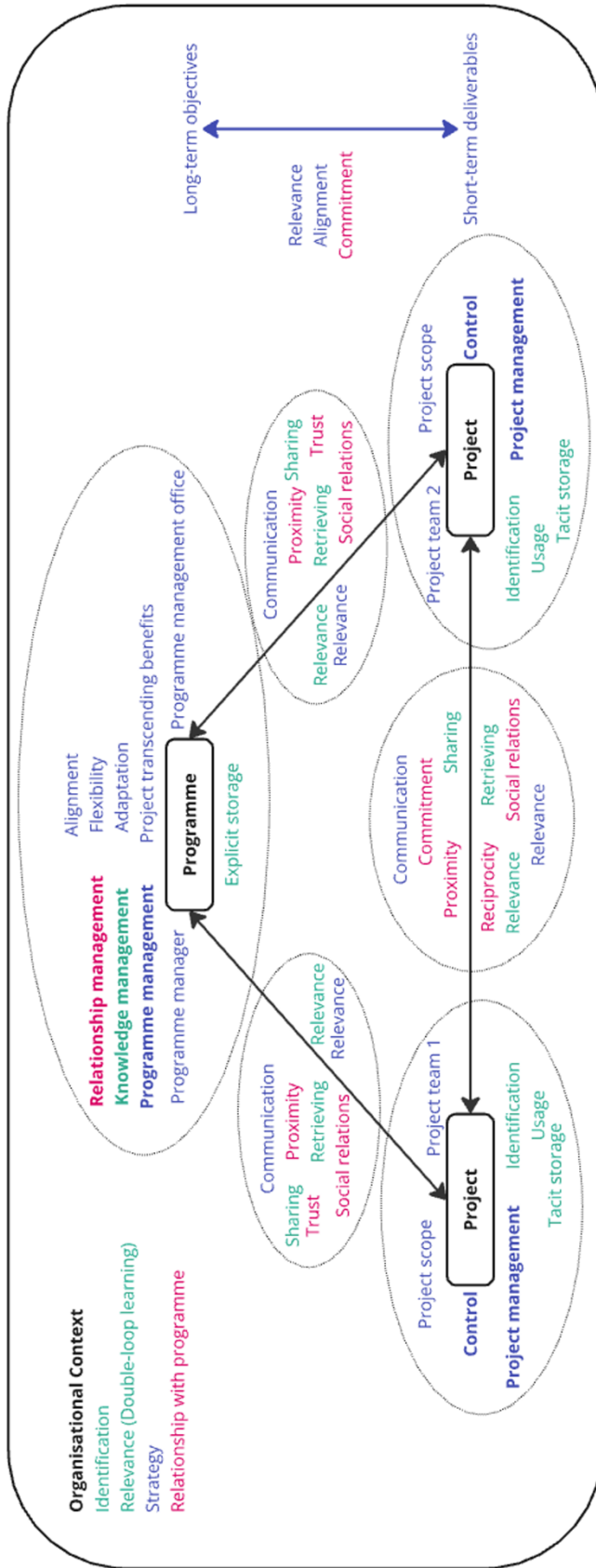
This figure presents the theoretical framework and where the different aspects identified in the previous chapters are relatively located. This figure allows for the comparison and shows the relations of the different aspects on three different levels: the project-, programme-, and organisational context level.

Figure 10.1 presents the theoretical framework as interpreted from the literature research. The basis of this framework consists of three levels: the organisational context, the programme-, and the project level. These levels were drawn up based on the example of programme organisation by PMI (2017a) and the relations mentioned by Lycett et al. (2004). Despite how it is depicted, this framework is not limited to only two projects. Many more projects can be organised parallel or (partially) sequential and it would only increase the number of interfaces.

Programme level
The three different types of management can take place because there is an overview of the programme and the subsidiary projects. It is at this level that knowledge and the relations between parties involved can be actively managed across the projects if necessary. Another reason is that the hectic of the projects can somewhat be relativised at the programme level. This allows for programme objectives and knowledge management not to be forgotten when a project is in full swing. This can then all be organised in the programme management office providing proximity between project teams and knowledge related activities such as presentations or project evaluations.

Because of the overview at the programme level, it is also useful to store knowledge on the programme level. When considering the SECI model, this would be related to the combination of explicit knowledge into for example manuals or reports. This could then be organised with for instance an intranet system or by translating lessons learned into best practices and manuals. Lessons learned from the different projects can then be collected and compared on the programme level. Relevance of knowledge stored should then still be assessed in cooperation with the project level because that is where knowledge should be used, and its value proven.

Organisational context level
Relations and relevance are the main aspects one can consider for the broader organisational level or context in which the programme operates. For knowledge management it can be necessary to identify relevant knowledge that can be used in the programme or the projects but cannot be obtained there. New technologies can for example be developed outside of the programme that can be beneficial for the work in the projects.

But relevance of the programme objectives is also something that should be considered due to the long-term nature of the programme. Perhaps there is an organisational change in strategy or new opportunities arise that are beneficial to include into an existing programme. This connects then to the relationships between people in the programme and the organisational context. There might not be a consensus on the relevance of the programme objectives in relation to the organisational context. If these differences are then not discussed or resolved, a lack of commitment can hurt programme success.

Project level
On the project level the 'regular' project work still needs to be executed. This means that the principles of project management still apply on this level. Unlike the programme level, a focus more aimed at controlling budget, time, risks, and project scope is thus still necessary here. The main goal of these projects is thus still to work on their deliverables. An important addition is that despite there being a focus on project deliverables on this level, the implementation of programme objectives should not be neglected completely.

When considering knowledge management on this level, the projects are the place where knowledge should be used and where knowledge through experiences can be identified. It is thus at this level that tacit knowledge stored within the individuals working on a project should be externalised when one wants to identify and share this knowledge.

Between different projects
Between different projects, there can be opportunities obtained by keeping an eye on the other projects due to the network properties of a programmatic approach. A benefit of the programmatic approach is though that this is then not just the responsibility of only the project team, but they can be assisted from the programme level. It can happen for instance that there is a sense of urgency within the project to deliver results to consider other projects or project teams. Activities can be organised from the programme management office to get people to know each other if this is not already the case to improve social relations. Also, because that is where the overview is of what other projects there are.

The knowledge shared between different projects can then also be different in relevance to if it were to be shared with the programme level. There can for instance be certain technical details that might only be relevant to two projects but not on the larger scale of the programme. It can then turn out however that for instance issues shared between projects are more frequent than first expected. This would then be a reason to share it with the programme level as well.

There is however then still the requirement as described by Lycett et al. (2004) that there is no inter-project rivalry. Individuals within related projects should be committed to share and retrieve relevant knowledge through open communication. Proximity and good social relations could then result in the reciprocity of relevant knowledge between relevant projects.

Between the programme and the project level
Between the project and the programme level, there are differences in the properties of projects and programmes that influence the relations between the two levels.

First, there is a difference in the timeframe of a project and a programme. A programme consists of multiple projects and can last longer than its subsidiary projects. It can therefore be difficult sometimes to show direct impact on the programme level from a project deliverable. This is similar with knowledge management, where knowledge is identified and stored to be reused in the future without perhaps seeing any direct impact.

This difference in timeframe also results in that on the programme level process management becomes more relevant. And this alignment with the organisational strategy and need for flexibility can influence the relevance of projects throughout the programme lifecycle. It is therefore important to communicate these considerations from the programme level to the project level. But it is also important to share experiences and insights from the project level to the programme level to create an understanding at the programme level if and how projects relate to the programme objectives.

When the programme and the projects then need to be organised, it follows that it is decided on the programme level which projects are relevant to do. It can be decided there as well what the projects should deliver in order to make sure the deliverables align with the programme objectives. The reasons behind this are the possibility of the programme to have an oversight of the other projects and because the relation with the organisational context is considered at the programme level as well.

There is however the risk that the programme becomes involved too much in how the projects should be executed. Since it can be assumed that the expertise for executing a project is at the project level, the project level should influence though how these projects are executed.

This distribution of insights and decision making is also the reason why trust between the programme and the project is important. On the project level, it should be trusted that the objectives of the programme are sound and that the project selected are relevant to this objective. On the programme level, there should be the trust that project teams know what they are doing and that there is no need for excessive control.

In can still be the case of course that things go wrong and that this trust is damaged. If for instance a project is selected on the programme level of which the project team states that is not relevant in any way, then these concerns should be made clear. But this also goes the other way around. when a project team is struggling with delivering relevant results, the programme manager should be able to share these concerns as well. And it might then even be needed to intervene.

This balance between the project- and the programme level also applies to knowledge management. Codified knowledge can for instance be stored on the programme level. Here, knowledge that is relevant to the long-term objectives and possibly to future projects can be stored. Again, the overview and understanding of the organisational context allows for this. On the project level there can however be a lot of expertise in the form of tacit knowledge that is relevant to the day to day work but perhaps not to the programme objectives. There should though still be an exchange of knowledge between the project and programme level because this might also influence and change the relevance of existing and new knowledge. Similar as to how programme objectives might change due to the relevance of new projects. Or how perhaps project deliverables can change because there is a change in relevance due to changed programme objectives.

Relation between programme objectives and project deliverables
Finally, it is important to mention the balance and the relation between the programme objectives and project deliverables. Programmes do not deliver individual project objectives, but project deliverables coincide with programme objectives. They influence each other and should be considered as such. Programme objectives and project deliverables should thus be aligned and relevant.

Project goals should not be forgotten though when one works within a programme. It are in the end the project deliverables that deliver concrete and practical value. But the way they are delivered and there relation to the broader context relates to the programme objectives. This however also goes the other way around: when there are for instance setbacks in projects it should not be the case that programme objectives are no longer considered within a project. Long-term value creation might otherwise be lost.

This balance of focus between project deliverables and programme objectives can differ between different programmes. Considering for instance the three different types of programmes as described by Rijke et al. (2014):
-   Portfolio style management,
-   shared service centre, and
-   Goal-oriented programme management.

With portfolio style management and the shared service centre, the project deliverables are considered to be more important. It is then the programme that through delivering their objectives supports the projects. With the goal-oriented programme however, the individual projects are there to contribute to a programme objective. This does not mean that these objectives are the same, but the focus is different. It is thus depending on the programme type where the balance lies between reaching the project goals and contributing to the programme objectives.

When knowledge management becomes part of the programme objective, the balance between project deliverables and programme objectives is similar to what is described above. As well as having short-term activities, it needs to be considered in a more long-term setting as well. Doing a project evaluation is an example of a short term activity from which a very practical deliverable such as a report can be the result. Creating and maintaining a knowledge database however is something that is an example of a long-term activity. It might for instance be needed to update this database, add new information and knowledge or check its contents for relevance.

Knowledge thus creates value when it is again used in another project at another time. Similar as to how a project can add to programme benefits, which might only take place after the project has finished. And to facilitate this exchange of knowledge, and the communication of objectives, good relationships are important between the programme and project level.

Another reason why knowledge management is a good fit to programme management is the project transcending nature of a programme. There is also a formal position, i.e. the programme manager, who is concerned with project transcending affairs. Knowledge management can be described similar to this as well: it is a project transcending system. Both programmes and knowledge management are however dependent and related to projects being carried out. One might even say that knowledge management is not only a condition for good programme management, but programme management is a facilitator for knowledge management.

11. Conclusions from literature

The following answers to the research sub-questions were identified from literature.

1. *How should a replacement- and renovation programme be organised when there is a focus on knowledge management?*

A programme is defined as a combination of related projects or subsidiary programs that are combined in order to achieve benefits that would not be realised if these projects were managed independently. Programmes should thus be organised consisting of related projects that add to the project-transcending objectives. These goals and objectives must then be clearly defined and communicated to all stakeholders.

Programme processes, structure, and organisation should be dependent on factors such as the degree of interrelation among the projects, the characteristics of the individual projects, and the nature of the organisations involved. Organising a programme management office is key for the organisation of programme governance, coordination, and adaptation. Programmes should thus be organised with a certain flexibility in its structures and procedures because of the relative long-term duration of a programme; it is likely there can be contextual changes. Enable the adjustment of specific project objectives to ensure that each project coherently contributes to the achievement of the overall program goals and benefits throughout the entire programme life cycle.

When considering knowledge management as a programme objective, activities and systems should then be organised on the programme level that allow for the identification, storage, retrieving, sharing, and using of knowledge between the subsidiary projects and stakeholders. These systems and activities should then consider the dichotomy of knowledge management where both 'social'- and 'codified' knowledge management are considered. Similar to a programme, knowledge management is about the relevance of knowledge and information. Knowledge management in a programme should then include topics such as how experiences from stakeholders relate to ongoing projects and to each other.

If one then also considers inter-organisational collaboration, a governance model that compares best to network governance is advisable for a programme. The reason being that both programmes and network governance rely on relationships. Programme systems and activities should thus be organised with the notion of relationships in mind, especially the relationship between the programme manager and the subsidiary project managers, The relationship between the programme and the organisational strategy, and the relationships between the individual projects.

How one then combines the three topics and relates their components and properties is presented in the theoretical framework of figure 10.1. This figure can be interpreted as an answer to how a programme should be organised when there is a focus on knowledge management

2. *What are the most relevant challenges related to knowledge management when considering a replacement- and renovation programme?*

Multiple challenges are identified from literature. First, related to programmes, project goals can become the main focus in a programme as a result of which the programme objectives and benefits receive less attention and might thus not be capitalised on.

Another challenge occurs when programmes do not allow for adaptation and flexibility. Then, the programme objectives might no longer match the wider (business) context overtime.

When considering knowledge management, tacit knowledge can be difficult to share or externalise. Specific activities thus have to be used such as causal mapping or the 'five whys' methods to reduce the 'tacitness' of knowledge
Something else that can result in a challenge is a difference in the interpretative framework of two individuals. This framework needs to be comparable in order to share knowledge instead of just sharing information, i.e. the receiver needs to understand what is shared.
Furthermore, there can be a tendency to consider one of the 'types' of knowledge management more important than the other. When social knowledge management is not considered, important tacit knowledge might not be externalised for instance through discussion. When 'codified' knowledge management is not considered, there is the risk of 'forgetting' or for instance knowledge getting lost through personnel leaving.

When regarding inter-organisational collaboration, a multitude of possible challenges arise. For instance, organisations might not be interested, committed, involved, communicating or contributing enough. This can result from organisations only looking for short term financial gains instead of long-term relational benefits.
Finally, challenges related to relationship in a network, or a programme are identified. First, since trust is an important aspect, a lack of trust is thus seen as a challenge. Also challenges in the relationship between the programme management and the individual projects can occur. For instance, an inappropriate amount of control from the programme manager on the projects. This would then result in excessive hierarchical bureaucracy and control and Focus on an inappropriate level of detail.
Regarding the relation between the individual projects, the challenge of inter-project competition is identified. In an environment of intense competition, projects operate so autonomously that they simply do not know what people outside their own team are working on.

III.   Empirical research

This section describes the empirical research that was carried out. As was mentioned in the introduction, this part of the research was done in collaboration with the Dutch engineering and consulting firm Witteveen+Bos. They have been awarded part of the framework agreement to recalculate bridges for Rijkswaterstaat and were involved in the early discussions on how this framework agreement should be organised as well.

The empirical research consisted of three parts:
1. Getting familiar with the organisation of the framework agreement   Chapter 11
   for recalculations and the 'bureau herberekeningen'
2. The semi-structured interviews that were conducted with   Chapters 12 & 13
   practitioners
3. The validation session   Chapter 14

Chapter 15 finally gives an intermediate conclusion that follows from the empirical research.

This section will attempt to answer the following sub-questions:
2. *What are the most relevant challenges related to knowledge management when considering a replacement- and renovation programme?*
3. *How do the roles and assumptions in the information and knowledge landscape influence the challenges in a programmatic approach?*

**Figure III.1:** The Moerdijkbrug

One of the fixed steel bridges that have been identified by Rijkswaterstaat to be recalculated is the Moerdijkbrug near Dordrecht in the Netherlands. Photo: Pix4Profs / Joris Buijs

12. Description of the recalculation framework agreement and 'Bureau Herberekeningen'

As described in the introduction of this report, the load capacity of many critical bridges in the Netherlands need to be recalculated with heavier modern traffic in mind. In order to recalculate hundreds of bridges within this decade, Rijkswaterstaat has signed a framework agreement in February 2024 with 10 different engineering firms for the recalculation of at least 250 steel, concrete, and movable bridges spread throughout the Netherlands (Rijkswaterstaat, 2023d).

This chapter gives a description of the organisation of the framework agreement and the 'bureau herberekeningen' in order to provide a better understanding. It is described here who is involved, what the framework agreement and 'bureau herberekeningen' entails, why it is organised as it is, and how the framework agreement and the 'bureau herberekeningen' are executed. This description has been drawn up on the basis of the tender documents (Rijkswaterstaat, 2023c, 2023a, 2023b, 2023d, 2023e), a collaboration covenant, through exploratory conversations with individuals involved (Appendix B), including a project start-up meeting where around 80 engineers and managers of all the parties involved were present. This chapter also explains further why this framework agreement was chosen for this research and why it could be assessed as a programme.

Figure 12.1: Organisation of the framework agreement
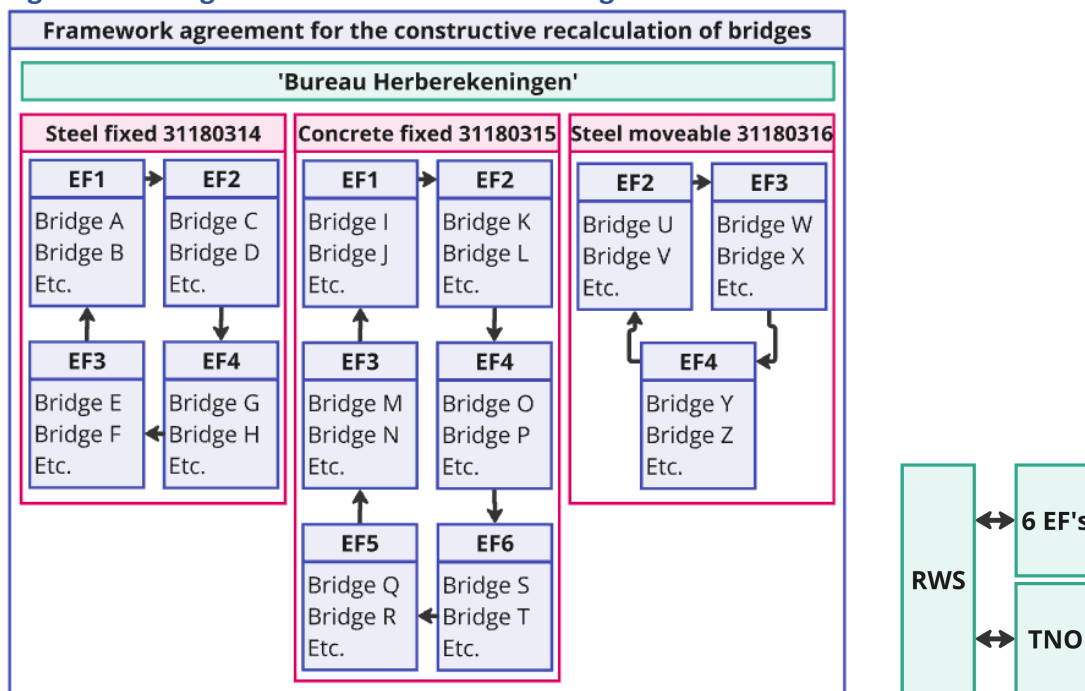
This figure shows the organisation of the framework agreement as described in the tender documents. There is a division of the bridges in three categories and the platform for collaboration and knowledge sharing, i.e., 'bureau herberekeningen'. The framework agreement was tendered per category. Each engineering firm (EF) or combination of firms was awarded a plot of multiple bridges within one of these categories. The sizes of these plots vary from 14 to 20 bridges per plot. The arrows between the different engineering firms represents how the different firms assess each other's calculations.

12.1.   The organisations involved

There are three types of organisations involved: A public client i.e., Rijkswaterstaat, the commercial engineering firms , and a research institution i.e., TNO.

Rijkswaterstaat, the Dutch National infrastructure manager and the public client for this framework agreement, is divided into two branches, the national- and the regional organisation units (Rijkswaterstaat, n.d.-a). It are these seven regions that form the basis for Rijkswaterstaat. They are in practice the true managers of the bridges in their region but for certain large- and executive tasks however, national organisation units were established. One of these national units is GPO ('Grote projecten en onderhoud', large projects and maintenance in English). It is this national unit that acts as the client in the context of this recalculation framework agreement. GPO is thus the middleman between the regions and the engineering firms and might even be considered to be the programme management organisation for this framework agreement. They also have the inhouse specialists that create the list of bridges that needs to be recalculated and that collaborate with the engineering firms.

The commercial engineering firms that have signed the framework agreement consist of ten different companies. Seven of these companies however were awarded the tender for this agreement within a combination, i.e. in a partnership. This means that on paper, only six parties signed the agreement. In practice, all companies are expected to collaborate but since the combinations are delivering their products as one it is considered in figure 11.1 that there are only 6 engineering firms working on the recalculations.

Finally, the Dutch research institute TNO is involved as well. Their role in this framework agreement is that of fundamental knowledge development. This entails for example the development of new calculation methods.

12.2.   What the framework agreement and the 'bureau herberekeningen' entails

First and foremost, the framework agreement is about quickly and expertly executing constructive recalculations in close collaboration with Rijkswaterstaat by simultaneously contracting several engineering firms. In the original tender, 221 bridges spread all across the Netherlands were selected to be recalculated in six to eight years. It was already noted however then that this number of bridges was not fixed and some people at Rijkswaterstaat mentioned that this number might still grow to 350 or even 400 bridges.

These 221 bridges were put on the market in three different tenders (Rijkswaterstaat, 2023b, 2023a, 2023d) with a separate tender per bridge category (table 11.1). Each category was then divided into a number of plots and each engineering firm could tender for one plot in as many categories as they liked.

Table 12.1: Bridge types divided in three categories

Steel fixed (4 plots)	Concrete fixed (6 plots)	Moveable steel (3 plots)
Plate girder bridges	Box girder bridges	Bascule bridges
Cable-stayed bridges	Viaducts with half-joints	Drawbridges
Truss bridges		Vertical lift bridges
Arch bridges		Swing bridges
Box girder bridges		

The framework agreement was divided into three bridge categories that each consisted of a number of plots. Each plot consisted of 14-20 bridges and an engineering firm could tender for all the categories, but only for one plot per category.

After all plots are awarded to the (combinations of) engineering firms, further agreements ('nadere overeenkomsten' in Dutch or 'NOK' for short) will be drawn up per project, i.e., per bridge. It is with this second agreement that the demand specifications and assignment details for a single bridge will be delivered by Rijkswaterstaat to the engineering firms. The engineering firm will then in turn send a quotation for that single project. Along with these demand specifications, available documents and information on the current state of the bridge such as drawings, possible QuickScans, inspection reports, and maintenance records will be supplied by RWS as well. If it turns out that these documents are not complete or if they're missing, the engineering firms are expected to perform an archival study or inspect the bridge themselves.

For the legal basis for the framework agreement and the further agreement, the terms and conditions are based on the Dutch ARVODI 2018, which are the general government conditions for the provision of services.

Despite it may have seemed as such in this report before, the 'bureau herberekeningen' is technically only a part of this framework agreement. The 'bureau herberekeningen' is originally drafted as "a platform for collaboration and knowledge management from which meetings, lunch lectures, expert pools and mutual assessments are organised" (Rijkswaterstaat, 2023c). The 'bureau herberekeningen' is thus where the real collaboration and knowledge sharing takes place between the different engineering firms. How this will be organised is described in sub-chapter 11.5.

12.3.   The reasoning behind the framework agreement and the 'Bureau Herberekeningen'

The main reason why Rijkswaterstaat has organised the recalculations is to "prove the constructive safety" of bridges in the Netherlands (Rijkswaterstaat, 2023c, p. 8). They want to get a clear insight about the physical state of a bridge. Bluntly said, they want to know if a bridge can last another 30 years, if it can last another 30 years if it is renovated or reinforced for example in the next ten years, or if it needs to be (partially) replaced because even with renovations it can no longer last 30 years. Along with knowing which bridge is then in need of renovation or replacement, they can also get the insight into which bridge is most critical. These bridges were selected by the specialists of GPO and Rijkswaterstaat because they believed these to be most critical.

Rijkswaterstaat can then combine the physical state of the bridge with the potential impact of that bridge if it were to be closed. Through this combination of risk and impact, they can prioritise renovation or replacement projects, i.e., which bridge needs to be renovated first.

Because of this goal of the framework agreement, i.e., identifying the current state of bridges, this framework agreement can be seen as part of the study phase (figure 11.2). This means that after these recalculations, there still needs to be another round for making renovation designs and construction.

Figure 12.2: Different phases of the renovation task
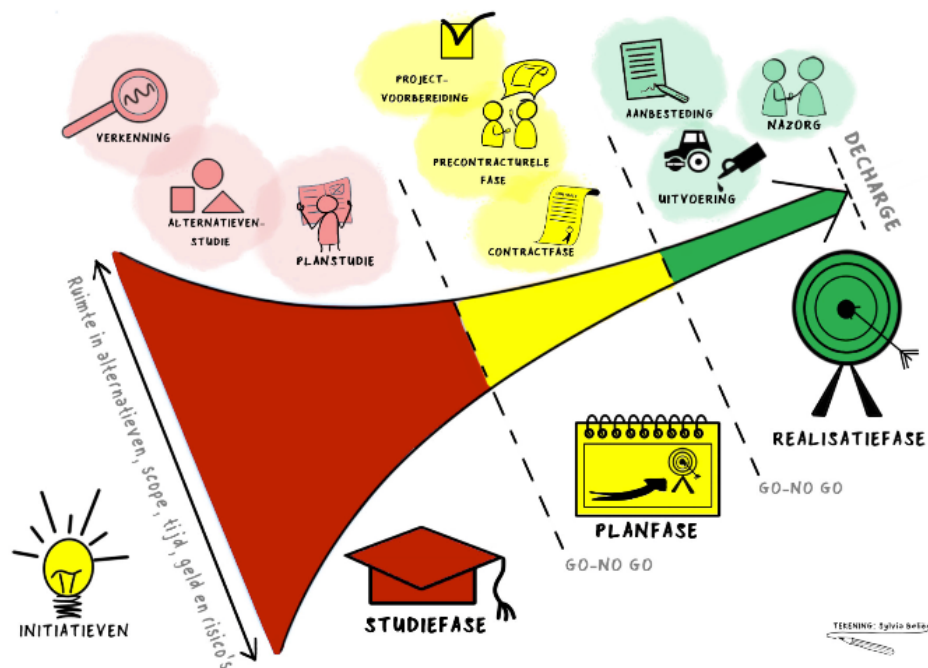
The organisation of the renewal and renovation task can be described similarly to this image. First, it needs to be identified what the current state of the bridges is, then renovation designs need to be thought out and organised, after which finally the bridges can be renovated. The framework agreement can be placed in the first phase here, where the state of the bridges is currently being identified before further steps are taken. Image: Provincie Noord-Holland (2021)

The reasoning why the recalculations were tendered as a framework agreement was mainly related to the decrease of the number of tender procedures needed. On the one hand, Rijkswaterstaat realised that if they were to tender every bridge recalculation project separately, it would simply take too much time.

On the other hand, market parties also wanted a decrease in the number of tenders but mainly from a commercial point of view. This wish for less tenders was made apparent to Rijkswaterstaat through market consultations (Rijkswaterstaat, 2021). The reason is that decreasing the number of tenders would also decrease the transaction costs related to the tendering procedures. Furthermore, it would also allow for engineers to work on the things they are good at, i.e., engineering work, instead of having to worry about winning a tender.

Another reason why this work has been outsourced is the notion that Rijkswaterstaat has a shortage of staff. This is also given as the main reason why the engineering firms will assess each other's work, because Rijkswaterstaat does not have enough personnel with the technical knowledge and skills to check all the recalculations quickly or extensively enough.

A formulation for the reasoning behind the 'bureau herberekeningen' was given in one of the tender documents (Rijkswaterstaat, 2023c). It is mentioned that from market consultations there was a wish for a more sustainable and future-proof solution, aimed at multi-year collaboration and knowledge development. The 'bureau herberekeningen' can thus be seen as the concretisation of this desire.

Part of this reasoning is the expectation that through sharing knowledge and experiences, the lead time of the recalculations will decrease significantly. For example, before this framework agreement was signed another large steel bridge in the Netherlands, the Haringvlietbrug, was recalculated as an individual project. It was mentioned in the exploratory conversations that the recalculation of this bridge lasted five years in total due to discussions on the assignment details, the methodology, and the assessments. For this framework agreement though it is expected that for the Moerdijkbrug, a steel bridge of similar size as the Haringvlietbrug, the recalculations will only last one and a half years. This is expected to be achieved due to the lessons learned from this previous project.

From this, the goal to "use, further develop, safeguard and share the limited available knowledge and expertise of Rijkswaterstaat and market parties with regard to recalculations as efficiently as possible" was formulated . It is this formulation of the goal that is the reason that this framework agreement was chosen for this research. This reason can be seen as a programme objective or benefit that is different from its subsidiary projects and that cannot be achieved by individual projects. The 'bureau herberekeningen' can thus be seen as the programme with the objectives of inter-organisational collaboration and knowledge management with the recalculations of a bridge as the subsidiary project.

Another reason for the 'bureau herberekeningen' is that there are many other smaller governments in the Netherlands such as municipalities and provinces that are also owners of infrastructure. This framework agreement can somewhat be seen as a 'pilot project' for this type of work and collaboration. It is also this reason why experiences and lessons learned from the execution of this framework agreement are important, because lower governments might not have the resources to allow them to organise and learn for themselves.

12.4.   How the framework agreement is executed

The work within the framework agreement consist mostly of three parts:
- Recalculating the bridges,
- Assessing and checking the work of other engineering firms, and
- Sharing, storing, and using knowledge

The recalculation work will take place as if it were individual projects. As mentioned before, 221-400 bridges need to be recalculated in six to eight years. The expectation is that the recalculation of 23 bridges will start in the first year. Some will be smaller concrete bridges that are expected to be done in two to six months whereas larger steel bridges are expected to take between one and a half to two years. It can be seen here again that a learning curve is expected where the pace of projects completed will increase throughout the years (6 x 23 < 221). Also, not all the projects will be done sequentially but semi sequentially as a network. An engineering firm can already receive the assignment details and the further agreement before finishing the first bridge.

The second part mentioned is the Assessing and checking of the work of other engineering firms. Thus, before the recalculations of a bridge are handed over to Rijkswaterstaat, it has already been reviewed by one of the other engineering firms. This will off course make sure that the quality of the work is sufficient and that there are no mistakes made. However, these assessments are expected to have two other advantages as well:

1. It relieves Rijkswaterstaat from having to completely assess all of the recalculations of all the engineering firms, and
2. It will somewhat force engineering firms to share knowledge on methodologies because they have to present their work for assessment to another engineering firm.

Especially the second advantage is an interesting one in this context. These engineering firms are commercial companies and perhaps even competitors for other projects. They might thus be reluctant to fully show their methodology and considerations to another engineering firm. There are however two consideration related to these assessments:
1. The frequency of the assessments throughout the project
2. The degree of involvement of the engineer that assesses the calculations

These two considerations are somewhat connected to each other and mostly come down to the following. When a project will last longer and be more complex, for example the recalculation of the large steel bridges, it is expected that assessments will need to take place more frequently. They should then also allow for the discussion of the methodology because if it is only checked at the end, it will take too much time. The downside of these frequent assessments however is that when the engineers that do the assessments become too involved, they will be less impartial.

Finally, in order to share knowledge, there is the 'bureau herberekeningen'. The idea behind this is that the engineering firms will be together at the office of GPO Rijkswaterstaat in Utrecht. During these days, lectures, presentations, and knowledge sharing sessions will be organised through expert pools per category of bridge. It is also expected of alle the engineering firms that they will commit to these expert pools.

Furthermore, these days are also there to allow the people working on the projects to for instance ask questions by just walking up to someone. It is expected that this will shorten the lines between the different parties working on the recalculations.

Something that is mentioned in the collaboration covenant and was discussed during the project start-up meeting but was not mentioned again in other conversations was the creation of a shared digital knowledge database.

13. Interview set-up

Following the literature study and the theoretical framework of section II and the description of the framework agreement from chapter 12, interviews were conducted in order to gather data and more in-depth insights. This chapter describes the interview set-up, the interview questions, and tries to assess biases that can be relevant.

First, the timing of the interviews needs to be explained. The framework agreement was signed in February 2024, this research started in the beginning of March, and the interviews took place in the second halve of May and early June. At the moment the interviews were conducted, the recalculations had not really started yet. The first assignment description for a concrete bridge had just been given to one of the engineering firms and there had not yet been a collaboration day in Utrecht. This resulted in the interviews being mostly related to expectations of practitioners.

It was decided to do semi structured interviews where a fixed set of questions was prepared but there still is the opportunity to discuss topics that might arise more freely. The reason that this was chosen was to get a comparable and perhaps quantifiable set of answers while still allowing the conversation to deviate if an interesting topic was introduced by the interviewee or if it was necessary to ask follow-up questions.

Before the interviews were conducted the questions, an introduction of the topic of this research and the goal of these were sent along with the invitation. The goal given was to "gain insight into possible practical challenges and trade-offs of the programmatic approach, knowledge management, and the future of bundling projects".
The interviews were conducted using Microsoft Teams and each lasted between 45 and 60 minutes. The reason why the interviews were done via Microsoft Teams had multiple reasons. First, many of the interviewees were located at different offices throughout the Netherlands making it easier to have the conversation digitally. Secondly, Teams allows for the automatic recording of transcriptions. With the consent of the interviewees, these automatic transcriptions were used so that there was no need to manually take notes. This allowed for the conversation to take place more naturally and allowed for full focus on the conversation without the distraction of taking notes. Finally, at the end of every interview the interviewee was asked if they had a final addition to the conversation.

An important part of interviewing is deciding who was to be interviewed in order to get a good insight. Therefore, two aspects are important:

1. making use of stratified sampling (figure 12.1), and
2. assessing possible biases before the interviews

Regarding stratified sampling (O. C. Robinson, 2014), the population was defined as the framework agreement and the groups identified were the organisation involved, i.e. Rijkswaterstaat and the engineering firms. The reason that these groups were chosen individually is because it can be assumed that the client has another interest than the engineering firms and will thus have another view on the framework agreement. The reason why the different engineering firms are also divided into different groups is that these firms might have a different level of experience with the client or with these type of projects as well as a different organisational culture.

Within these groups, it was decided to again make a differentiation between positions within the organisations. It was decided to select employees with the functions project manager, technical manager, contract manager, engineer, and expert. But also, for the engineers for example, it was decided to interview junior- as well as senior engineers. The reason being that it was expected that there might be a difference in the willingness to share between the different positions and between the different seniorities.

Figure 13.1: Stratified sampling
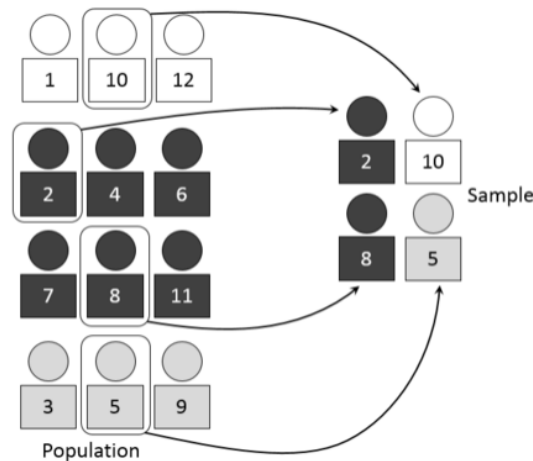
This figure shows the principle of stratified sampling (Kernler, 2014). The population for the interview consisted of the organisations involved with the framework agreement of which every organisation is then a separate group. From these groups, a sample was composed from different positions within the organisation such as engineers and managers.

The expected results for these interviews consisted of three parts:
1. Insights into the execution of the framework agreement and the 'bureau herberekeningen
2. Insights into the challenges expected with knowledge management
3. Insights into the assumptions and views of the different organisations

13.1. Assessing Biases and assumptions
Something to consider when drafting the interview questions is that the interviewees might have biases related to the type of organisation they work at. This sub-chapter presents the biases that were considered for the interviews.

For the engineering firm, the main bias assessed here relates to their commercial nature. This might result in them being competitive towards other engineering firms. Because knowledge is their product and because they might compete on projects outside of this framework agreement, they might not be willing to share their knowledge. At the project start-up meeting for instance, there was a discussion about sharing the workings of the calculation software that engineering firms developed. It showed then that this was a sensitive topic because these firms invested time and money in this software and were not keen on sharing it.
Also, it is assumed that they will be critical on the pace of the client because they have a performance driven mentality. It is expected that the engineering firms can be eager to get the work done and thus can be critical on the pace of the client.

For Rijkswaterstaat it is expected that them being a public client will likely have the most influence. Because they are a public party, they might be less performance driven than the

commercial parties. This might lead to them making decisions less quickly which results in annoyance from the engineering firms. This might also result in them not being able to change their practices quickly when needed.

This might also relate to them having the responsibility as the asset manager. This might show in Rijkswaterstaat not wanting to let go of control much on how things should be done and will feel that they have to validate every decision. This might then show in more bureaucratic tendencies and by sticking more to the contracts. Also, it might be that Rijkswaterstaat will be less critical on 'their' methodology, i.e. this framework agreement.

Finally, the biases of this research need to be considered. Because this research was conducted in collaboration with an engineering firm and because the tendency to be more in agreement with the commercial side, it should be considered that the questions should not bias towards the commercial side of the framework agreement.

Furthermore, this research agrees with the use of a programmatic inter-organisation as a possible solution for the renovation task. It is therefore chosen to try to identify challenges related to the programmatic approach and knowledge management. Also, because these might be more difficult to identify when one is not directly involved.

13.2.   Interview Questions
In this sub-chapter, the interview questions and the reasoning behind their formulation is discussed per topic. The three topics chosen here are the programmatic approach, knowledge management, and looking forward at the 'bureau herberekeningen'. It is described for every question how they relate to the theories from section II or how they followed from the exploratory conversations.

Programmatic approach
1.   *According to you and in your own words, what is the goal of the 'bureau herberekeningen'?*
2.   *What do you think of meeting one day a week in Utrecht? Will this work?*
3.   *How are the relations within the 'bureau herberekeningen'? Can a certain degree of partnership arise or will there still be a client-contractor-competitor relationship?*

The first question was formulated because of the definition for a programme used in this research. Because this research tries to assess the framework agreement as a program, it is interesting to see if the people working on it also think this framework agreement has a project-transcending objective. Also, it would be interesting to see if the interviewees would answer the same or similar goals in their answers. This would then show if these potentials goals were communicated clearly of if there is a difference in what people find relevant.

The second question is formulated to check if the aspect of proximity as it was described by Li et al. (2022) in literature and the expectation of working together at the Rijkswaterstaat office would result in the same expectations. It is expected in literature that bringing people closer together will help communication, collaboration and knowledge sharing. This could give an insight into inter-organisational collaboration and the possible relations between theory and practice. The question asks for expectations though because these collaboration days had not started yet.

The third question was formulated because the statement of Lycett et al. (2004) that all of the challenges can be when programme management is used can be related to the inefficient management of relationships. It was decided to assess how the theory on relations in inter-organisational collaborations holds out in the context of the 'bureau herberekeningen'. This question assesses if competition between different commercial parties is also a challenge here or if there are other things in play. The reason for this is that in literature it seems that most of what is written relates to programmes within a single organisation or company. It is therefore relevant to find out more about this collaboration between possible competitors. This question can also assess if there are different viewpoints from different organisations on aspects such as willingness and commitment.

Knowledge management
4. *What do you regard to be relevant knowledge and what knowledge do you want to receive from other organisations? E.g., experiences, insights, reports, data, methods, results, or something else?*
5. *Will competition between the different organisations become a challenge for sharing knowledge? To what extent are the engineering firms prepared to provide insight into what they do, how they do it, and what they know?*
6. *Will checking each other's work help to promote knowledge sharing by providing insight into each other's considerations and methodology? What would it take to facilitate this, e.g., level of insight, openness, willingness, or something else?*

Question four relates to the definition of knowledge as is given in chapter 8. Because relevance can be a subjective term, this question then tries to assess which parties find which knowledge or information relevant in this context. The questions uses the word "receive" instead of "share" because people might be more reserved to answer a question that may sound like they are giving something away. Some examples are given in this question, because these examples contain both implicit- and explicit knowledge. It might thus be interesting to see if people value implicit- over explicit knowledge.

Question five is asked because on the one hand it relates to one of the challenges mentioned in literature by Lycett et al. (2004). On the other hand, this is something that became apparent during a discussion at the project start-up meeting. It became apparent there that organisations were not keen to truly give insight into their calculation tools and software.
On the one hand, this question thus tries to find out if competition between projects is a challenge when different projects are executed by different commercial parties. On the other hand, this question tries to find how willing engineering firms are to share knowledge.

Question six was based on what was mentioned in the exploratory conversations by someone from Rijkswaterstaat: that the assessment rounds between engineering firms can also be used to share knowledge and not just to check the quality of the work. It is expected that because engineering firms need to check each other's work, they will get more insight in each other's reasoning and results from which they can then learn and improve their own work. This is an interesting notion, and this question therefore tried to assess if others also looked at it this way. Especially because involvement in other projects is not something that stands out from literature. It can be very interesting though to see if this type of involvement can be beneficial for knowledge sharing and the programmatic approach. The second part of this question is there to then assess what conditions are relevant in order to have this successfully take place.

Looking forward at the 'bureau herberekeningen'

7. *If you could mention one point, what might be the biggest challenge for the 'bureau herberekeningen'?*

8. *If it turns out that collaboration and knowledge sharing via a programmatic approach does not work as intended, is it still necessary to work with separate projects and tenders again?*

Question seven is a bit of an open and direct question related to the second sub-question. The reasoning here was to not directly ask this question at the beginning of the conversation but more to the end when the conversation was already going for a while. This might then result in interviewees being more open and coming up with things more easily because they have already been talking and thinking about the topics for over half an hour.

Question eight was asked to check a statement that was described in the introduction, and which is a bit of the foundation of this research: a programmatic approach should be more beneficial than individual projects. This question was also used as a bit of a closing question to get to a final conclusion for the conversation.
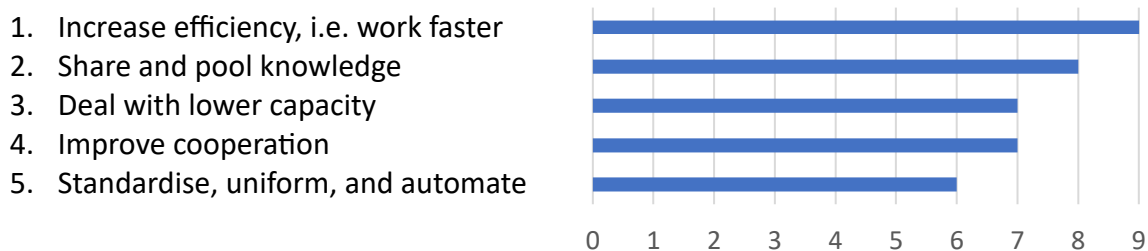
14. Interview results

After the interviews were held, the transcriptions of each interview were analysed and filtered per question. Once sorted per question, the answers of the different interviewees were compared and the most notable differences, similarities, or answers are discussed below.

In total, 12 interviews were conducted. Seven interviews were held with employees from two engineering firms with positions ranging from junior engineer to senior engineer, to manager. Five interviews were held with employees of Rijkswaterstaat with positions ranging from project manager to contract manager, to project manager. An overview of the interviewees and interview dates is given in Appendix A. The interview transcriptions are not attached to this report due to privacy reasons but can be requested from the researcher.

In the graphs of this chapter, it is shown how many different interviewees mentioned that topic. Because an interviewee was able to give multiple answers, the sum of the number of answers does not match the sum of the number of interviewees.

14.1.   The programmatic approach

1. According to you and in your own words, what is the goal of the 'bureau herberekeningen'?

1. Increase efficiency, i.e. work faster
2. Share and pool knowledge
3. Deal with lower capacity
4. Improve cooperation
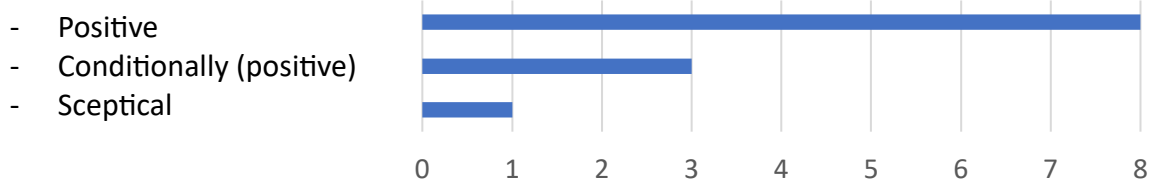5. Standardise, uniform, and automate

Given above are the five most mentioned goals for the 'bureau herberekeningen'. First off, it needs to be stated that, similar to how the organisation was originally described (sub-chapter 11.2), the interviewees seemed to assess the 'bureau herberekeningen' separately from the recalculation projects. They seemed to consider it as the part of the work where knowledge must be shared, but not really as part of the 'regular' work. An example of this was the following statement: "in the end, the goal is to recalculate the bridges, but you don't need the 'bureau herberekeningen' for that". When considering the theoretical framework from chapter 10, this statement can be linked to the commitment and alignment to the long-term objectives and the short-term deliverables.

Despite it not being explicitly mentioned here, there seemed to be consensus on an overarching goal: more needs to be done in less time and with fewer people. And despite it was mentioned as the number 2 goal, sharing and pooling knowledge was mainly mentioned as a sub-goal for increasing efficiency. There really seemed to be a sense of urgency that there needs to be insight into the condition of the bridges quickly. This seemed to be the case for the engineering firms, as well as Rijkswaterstaat from which someone stated: "we can only speed up if we also learn from each other, because if we all bump into the same rock or keep bumping repeatedly, we won't go any faster".

One interviewee however mentioned a contradiction between the wish for knowledge management and efficiency for the recalculation of concrete bridges. Because the remuneration for concrete bridges is lumpsum, one can expect a negative incentive: "you make the most profit by doing as little as possible for that fixed sum. So, you never get that

trust and knowledge sharing because why would you do that? you don't get paid for that, it will just cost time and money and so you'll never do it".

2. *What do you think of meeting one day a week in Utrecht? Will this work?*

-   Positive
-   Conditionally (positive)
-   Sceptical

(Bar chart showing: Positive = 8, Conditionally (positive) = 3, Sceptical = 1, with x-axis from 0 to 8)

As described in sub-chapter 11.5, part of the 'bureau herberekeningen' is to have personnel from the engineering firms meet once a week at the office of Rijkswaterstaat in Utrecht. When these interviews took place though, such a collaboration day had not yet taken place. The answers given here are thus based on expectations and experiences from other projects.

The majority of the interviewees had positive expectations for these collaboration days. This then connects to the theoretical framework that proximity is necessary in the programmatic approach. The advantages mentioned for instance were:

-   "Getting to know each other better and finding each other even better is really an important prerequisite for sharing knowledge"
-   "It is good for team spirit".

There were some conditions mentioned though in order for these days to take place successfully:
-   It must lead to clear added value
-   These days must be organised usefully

It must lead to clear added value
There must be enough people willing to be there. "Just by being there you learn that you can get information here".

These days must be organised usefully
Determine what individuals want, what fits best during which phase of a project and be aware of the consequences of each activity. Four different options that were mentioned are:
-   Have people do their regular work there
-   Plan meetings
-   Plan presentations and knowledge sharing sessions
-   Allow for informal get-togethers

Having people come over to Utrecht and just work there on their recalculations seems to be the most straight forward. The benefits of being there without having any planned activities or obligations is that one is more likely to be available when someone else has a question or wants to discuss something. There is a risk however when people don't know each other very well yet. It is likely then that one "will probably just sit together with people from your own company".

There will be meetings where multiple organisations are expected to be present such as technical assessment meetings between engineering firms or progress meetings with the client. Coming together in Utrecht would then allow for these meetings to take place in person. Also, if people are reluctant to come, then this might somewhat oblige them to be there, after which they will hopefully see the advantages.
It may have the consequence however that because it is convenient to plan these meetings on the collaboration days, that someone will only have meetings on these days. This then means that they are no longer available for something else and there is then no longer the opportunity for others who are not in the same meeting to approach them ad hoc and ask questions.

Planning presentations on these days is seen as an easy active knowledge sharing session. The contents of these presentations could then either be something technical and related to specific methods or they could be related to experiences, either from these projects or somewhere else. An example given is to present something as simple as "I ran into this; we solved it this way. In order to share that information more consciously". Even more preferably would be that it would then not only be a one-way knowledge sharing session, but that there is the chance to have a discussion, for instance on "certain things that you want to do uniformly".

Finally, it was mentioned that there should be room for informal get-togethers. The result of getting to know other people from different organisations better would then be that "you just walk up to someone or even just sit at the coffee table and just talk openly about something like: I've come across this and then someone has probably come across that, or not". Someone from RWS mentioned the desired scenario where "after a while we will no longer know belongs to which organisation".

The scepticism that came from the interviews was related to the consequences of having employees work outside of their familiar workplace. Someone from RWS mentioned that "In principle, many people are taken out of their rhythm". Someone else from the engineering firms however mentioned that the engineering firms involved "are generally parties that are used to being at a construction company during a tender where more is required than here".

3. *How are the relations within the 'bureau herberekeningen'? Can a certain degree of partnership arise or will there still be a client-contractor-competitor relationship?*

-   Positive about partnership and cooperation
-   Cautiously positive, with recognition of challenges
-   Sceptical or critical of the current situation and the possibility of change
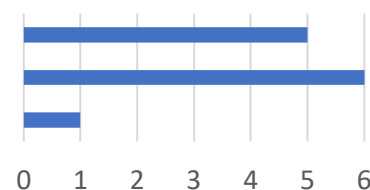
As mentioned earlier, when these interviews were conducted, the recalculations had not fully started yet. This means that the answers given here are related to the start-up phase and the expectations of how things will turn out in the coming years.

The benefit of how this framework agreement and further agreements are organised is that because the framework agreement has already been tendered under competition, there is the possibility for the client and the engineering firms to have an open discussion on the specifics

of the further agreement such as scope, budget, time. This allows for the engineering firms to think along with the client. One of the engineers for instance expects much from the expert pools: "I see a lot of opportunities there to take a step further together".

The work is however just getting started and people are still getting used to this collaboration, which might also be the reason that more people were cautiously positive. There is though the expectation that technical staff, i.e. engineers, will be able to collaborate just fine from the start.

Furthermore, the relationships are expected to positively develop over time, but "it is necessary that you have enough work and that you see each other. These are two necessary conditions to get the relations right". Competitive relations between different engineering firms are not expected be a much of a challenge, especially between engineering firms who have already worked together in the past. This would then connect to the social relations, commitment, and communication between projects as shown in the theoretical framework of chapter ten.

The challenges mentioned though seemed to mainly concern the relationship and collaboration between the client and the engineering firms. It is mentioned by people from RWS as well as individuals from the engineering firms that here will always be some sort of distance between the client and the engineering firms. But there is also a hope that these lines will somewhat fade as someone from RWS mentioned: "boundaries remain and ultimately Rijkswaterstaat remains the client. But I certainly hope that those boundaries become somewhat blurred". This statement as well as the following statements are related to the relation between the project and the programme level as shown in the theoretical framework of chapter ten.

There seems to be a realisation at the client that they also have to be willing to listen to criticism to get there, as someone from Rijkswaterstaat mentioned: "you have to be open to criticism, change if the engineering firms say they cannot do everything well if you as Rijkswaterstaat do not organise certain things differently". Someone from the engineering firms mentioned though that "there is simply no listening, by no one within Rijkswaterstaat. All they say is no, we'll do it this way".

Engineering firms also mention that there seems to be a lack of trust from the client. That individuals higher in the hierarchy of the client are afraid that market parties take advantage and will unnecessarily do more work. This would have resulted in the further agreements and the contents of these assignment descriptions to be too extensive and unnecessarily detailed because RWS wants to stay in control. This resulted in the engineering firms thinking that the pace at which the further agreements are getting through to the engineering firms is considered to be slow. A contract manager of the client however states that "we have discussed a complete procedure in the framework agreement on how we arrive at those further agreements" and that it's also a large endeavour for them to undertake. "That's not something that's easily done for us as well".

One argument was given to answer what the motivation is for engineering firms not to just bill a lot of hours and keep working on a single bridge. Aside from the intrinsic motivation that engineers do not like to do useless work, there also is the group aspect of the inter-organisational collaboration. Because multiple organisations work on similar bridges, it would stand out if an organisation were to be more expensive or takes more time to finish a recalculation. And it seems less likely that all engineering firms abuse the client's trust, as long as the nature of commercial parties remains to be competitive and outperform the

competitors. Furthermore, it would not be in the interest of an engineering firm to benefit on the short-term and potentially damage the client's trust because of the long-term nature of the programme. This also can be related to the alignment of long-term objectives to short-term deliverables of the theoretical framework in chapter ten.

The scepticism and criticism of the current situation and the possibility of change came from someone from the engineering firms who feared that the contracts might still be leading in the collaboration. He feared that apart from how it might seem now, the execution of the work will still be the same as it has been before. This would then result in not being able to reap the benefits of having open discussions as described earlier. It was said that it "depends on the people, whether they put the contract first or whether they put collaboration, learning and innovation above." This again relates to the alignment of the long-term objectives to the short-term deliverables.

Someone from RWS however also mentioned this risk but had a positive expectation: "we must now deal with the first problems with an open mind. If we, as an old-fashioned client, immediately say no, then it won't work. We now have to provide a buffer for those first small problems and not immediately take out the contract. If we keep that cool, I think we'll be fine."

14.2. Knowledge management

4. *What do you regard to be relevant knowledge and what knowledge do you expect to receive from other organisations? E.g., experiences, insights, reports, data, methods, results, or something else?*

1. Methods and methodologies
2. Insights and experiences
3. Tools and software
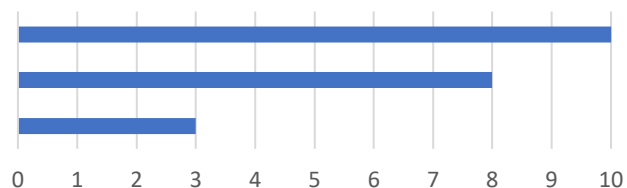
Two things that apparently are interesting to know in this context is what the others are doing and why they're doing it like that. It seems that a behind the scenes view of considerations and decisions made is seen as most relevant. It seems to be that it is not as relevant how the other engineering firms are doing what they're doing. Calculating tools and software is not something that is considered as most relevant. This can be between the project- and the programme level, i.e. between the engineering firms and the client, but also between the different projects on the project level (figure 10.1). The latter can be seen interesting because knowledge is shared on the level where the work takes place.

Some quotes that substantiated this were:
- "What does one do and what does the other do? What problems do they see? Those should be the themes here."
- "Because one party might deal with the same problem in a certain way, and a competitor might deal with the same problem in a completely different way. Well, that is interesting to know in terms of knowledge of how you deal with that and how the client sees it."

Understanding why other engineering firms do what they do might also give an insight into which steps are critical for correct recalculations. It might also show what is not necessary or what can be improved: "there are also many cases where you can say that we actually know

very well in advance that we can calculate this very well, but that it has no added value because we already know that it is either very good or very bad".

If it turns out that there really are steps that one always can or cannot do, then it "can perhaps result in a joint approach". However, "this also includes the insight into why something does or does not work better, because if we all start using something different at some point, then that is interesting and then the question is, why do we actually do that?"

This understanding then goes both between all parties involved. Thus, engineering firms understanding the reasoning of other engineering firms, the client understanding the reasoning of engineering firms, and the engineering firms understanding the reasoning of the client: "why was this division of the bridges among these engineering firms chosen, what has already been done in the past and why do they want certain things or not?"

One reason why these methods and insights are seen as more important was given by two individuals from the engineering firms: that recalculations really are a craft. "You are always on the edge of what is possible and what the standards say. You often have to improvise, and it requires a lot of insight into the construction". And: "what helps enormously is that if you encounter things that deviate from the norm, you share that."

5. *Will competition between the different organisations become a challenge for sharing knowledge? To what extent are the engineering firms prepared to provide insight into what they do, how they do it, and what they know?*

1. Reciprocity is key
2. Software is sensitive
3. It will happen anyway
4. There is no competition
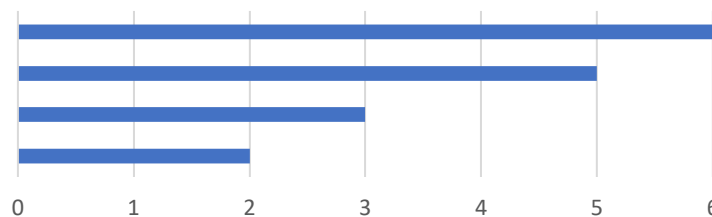
The main condition given for competition not to become a challenge is reciprocity: a mutual exchange from which all parties involved benefit. This will then mostly be relevant on the project level (figure 10.1). Most expect that this will not be much of a problem on most occasions. One concern mentioned here however was that there might be engineering firms with noticeably less experiences or knowledge than others. Because they would then have fewer insights to share, it will result in "inexperienced parties retrieving more knowledge, so there must then be something to be gained from training your competitor's staff". Something that is in direct contrast to this statement is something that is mentioned least here: that there is no competition. Every engineering firm has already been awarded at least one plot of 14 to 22 bridges, and some even more: "we do not compete with each other on objects, everyone gets a piece of the pie, and everyone benefits from it".

It is interesting here that despite It was not mentioned as relevant knowledge much, sharing the tools and software was more often mentioned here as being sensitive. Because "that is just corporate property, the intellectual property". Someone from RWS interestingly mentioned though that "there are a number of parties that may still think that their working method or their calculation model is a unique factor. That they compete on that. It will be interesting to see in the coming years whether that is the case". "Perhaps we will come to the conclusion that the calculation model is actually something that you could also share with each other and that the software that is used costs everyone a lot of energy, time, money and effort, while there is actually no distinguishing difference". It might be interesting thus to see if the

'bureau herberekeningen' will show what actually is "knowledge for everyone and when are you going to say: this is what I compete on?"

Finally, others say that the discussion on competition is mostly a start-up problem. "The collaboration will improve because no one benefits from withholding things". "We will be working together for 6 years, we work on the same themes, so it is inevitable that a similar level of knowledge will arise, so why oppose that?"

6. ***Will checking each other's work help to promote knowledge sharing by providing insight into each other's considerations and methodology? What would it take to facilitate this, e.g., level of insight, openness, willingness, or something else?***

Unanimously yes: engineering firms having to present their methodology and results to another engineering firm will positively contribute to knowledge sharing.
There were some conditions specified for these assessments to take place properly though:
- Openness to share,
- Constructive and judgment-free criticism, and
- The degree of involvement of the assessor

First, there is the need for an open atmosphere in which engineering firms are willing to share their work. The assessment rounds are part of the contracted work. Someone from the engineering firms therefore mentioned that "you are more or less forced to show what you have done to the other engineering firm, which makes it a very good way to get people to get used to sharing knowledge". And perhaps even at some point sensitive topics such as the contents of the software and tools will be shared: "maybe they will change their mind over time, but that is a long way off".
The big chance and the preferable scenario here is that this openness will result in some sort of knowledge "crosspollination". When two engineering firms can openly discuss a certain recalculation, then they might both be able to learn from each other. The benefit of this then is that "If you see how others have approached the calculations and if you see smart things there, you can use them again for your own work". This is the part of the work where you have to "open yourself up to the other and vice versa. And if that doesn't work, then you know the rest won't work either".
There was the expectation overall that these assessments would be helpful and successful. Especially because the assessor and the assessed are both engineers from a similar organisation. Someone from an engineering firm gave an example from another project where a client hired an assessor from another engineering firm: "he was also practical; he also did recalculations himself and that was useful".

Another condition mentioned was that of constructive and judgement-free criticism. Someone from the engineering firms summarised this in the sentence "test the way you want to be tested yourself". Added to this was also that one should "definitely not cross out errors in the reports with red lines".
This however also goes the other way around. "Suppose that the party that checks it does not understand something. Then those two parties have to talk to each other". "There are some parties that are less experienced and thus have to get to the level of the others". But that less experienced party can then watch how the more experienced party works, because then they can learn from it. Also, "there are no stupid questions, so it can help when someone says I

don't think it makes sense, explain it to me". "That can sometimes lead to someone saying, why did we do that?" The point made here is though that also when the assessor asks a question, it should not be waved away by the assessed party as something they should have known.

Finally, the degree of involvement of the assessor is another condition mentioned. This consideration was also shortly introduced in sub-chapter 11.4. but was mentioned in the interviews as well.
It was mentioned that for steel bridges for instance, "the assessor is present at the technical meetings every two weeks" The advantage then is that the assessor can really follow what is going on with the calculations of the other firm. The assessor can then quickly help if needed. But also, when things are running smoothly, the assessor can really see why and how the other firm does something.
For the concrete bridges however, "this fortunately is not the case". "We will test it afterwards". There was however a condition mentioned to this as well: "it is good when one party makes a calculation that they also know which company will do the testing and preferably also which person. "So, if there really are discussion points that you at least know who you have to go to. They have to test is, let's go and see what they think about it".

14.3.   Looking forward

7. If you could mention one point, what might be the biggest challenge for the 'bureau herberekeningen'?

1. Collaboration and communication
2. Low pace of further agreements
3. Letting go control by RWS and having trust
4. Limited capacity of RWS
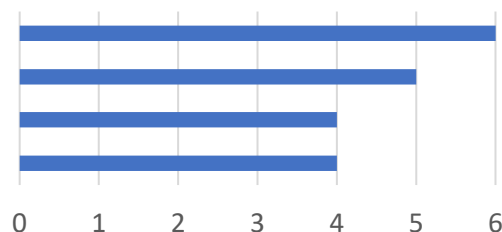
It has to be mentioned here again that these interviews took place when the actual recalculation work had not started yet. This means that the answers given are mainly expectations or related to the start-up phase of the framework agreement. This might also explain the challenge that was mentioned most: collaboration and communication.
Someone from Rijkswaterstaat for instance mentions that "the most challenging thing is that we indeed become the 'bureau herberekeningen'". Or someone from the engineering firms mentions that "the biggest challenge is the willingness to achieve that collaboration". It should not be the case that "everyone just says I'm happy with my own club here, it'll be fine." Someone else from an engineering firm added to this: "you really have to avoid becoming a multi-project organisation where everyone stays in their box. So, you really have to push this. Because if you don't do that, especially at the beginning, it will fade away."
One more specific aspect that was repeated as a potential challenge here by one person from the engineering firms is that the potential difference in expertise of different engineering firms hinders willingness for collaboration. "If you happen to be the one who has to test a calculation by someone who doesn't know much about it, then you are mainly busy one-sided talking to send back your knowledge." "I don't think that improves the mutual atmosphere. If the same

people come to you every time to collect knowledge. That at a certain point you think there they are again."

For the other three answers that were mentioned, there seems to be somewhat of a connection between those answers: they seem to all be related to the actions of Rijkswaterstaat and they relate to each other. This connection is shown in the figure below.

Figure 14.1: The connection of challenges identified
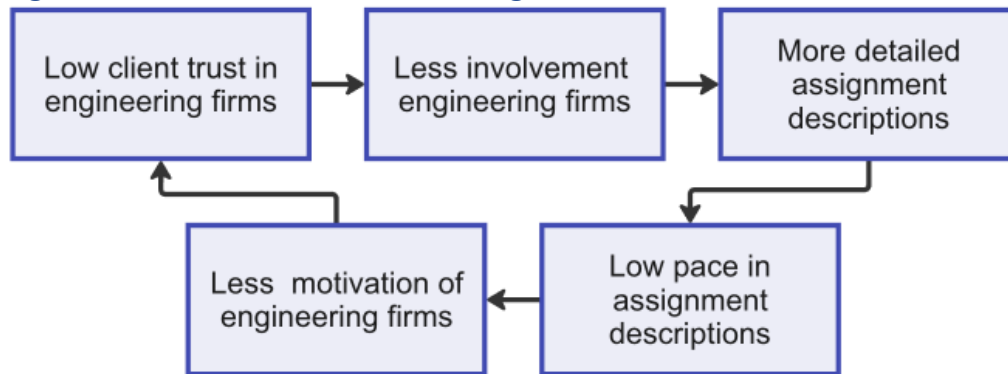
When considering the challenges mentioned in the interviews, a cycle seems to evolve. It is this negative spiral that should be broken in order to improve the pace of the further agreements and the assignment descriptions per bridge.

All but one of the answers related to these challenges were given by individuals from the engineering firms. One of the reasons for the low pace given is that because the duration is six to eight years, people are not really feeling much pressure to deliver. Someone from the engineering firms mentioned of this that he thinks it is "a big challenge when people think well, I'm working well, let's just take our time".

Another reason that the pace is low is related to the fourth answer: Rijkswaterstaat probably does not have enough people to have the further agreements and the assignment details ready quickly. One person from the engineering firms mentioned "the biggest challenge mainly lies in the relationship with the client, that they have very little capacity with a gigantic assignment". Or someone else stating: "I still think that Rijkswaterstaat is the limiting factor. they probably do not have sufficient capacity. You can actually already see it developing during the further agreements, which have been delayed for two months". Someone else from Rijkswaterstaat however disagreed and said that engineering firms needed to be more patient because "We've only barely started".

The fourth answer given for this question is also seen as a reason for the low pace: that Rijkswaterstaat does not like to let go of control over the projects. Thus, not only does Rijkswaterstaat not have enough personnel, the engineering firms think that they also make the assignment details and further agreements too extensive and unnecessarily detailed. Someone from the engineering firms mentioned that Rijkswaterstaat needs to "stop trying to be involved in every decision". Another engineer suggested: "don't start by describing everything you want on paper and closing it all down. No, just take us along in your overall challenge and make it so that your challenge becomes my challenge. If we can go there, then you have a much more effective process on the front end." Someone else added to this that Rijkswaterstaat ""then saves themselves writing epistles of 60 to 70 pages that you read through once, then you think, okay, nice, but?" Another engineer mentioned even that "There is no trust at all, or they want to stick to the plan. They came up with something and that is

good. But that is not what collaboration is about. So, I can already see how things will turn out. If this continues, it will be a fiasco. The fun has really gone completely".

The one person from Rijkswaterstaat that mentioned this challenge as well said that it "requires a change or improvement that should perhaps be implemented now so that market parties may also be more involved in that process. Firstly, to better understand what your problems or problem points are that are difficult about the part you are doing now and perhaps you can also share those uncertainties."

8. If it turns out that collaboration and knowledge sharing via a programmatic approach does not work as intended, is it still necessary to work with separate projects and tenders again?

Unanimously: no, in order to successfully tackle the renovation task, it is necessary to bundle projects in an organisation such as this framework agreement.

From the engineering firms, some statements were:
-    "It has to work. Even if it works fairly stiffly, this is already better than the way it was. Even now that we are not actually busy yet, this is already more pleasant than it was."
-    "No, going back to what it was must be avoided at all costs.
-    "Failure is not an option, otherwise you will never achieve sufficient results"
-    "If that collaboration does not really get off the ground, then this environment where you will recalculate 19 objects within an x number of years still better than the old approach"
Employees from Rijkswaterstaat also mentioned:
-    "No, the tendering method will remain the same"
-    "Individual projects are not an option"
-    "Everyone on our side is absolutely committed to making this happen"
-    "If it doesn't work here, then we have a serious problem"
This shows that both sides are in favour of combining projects but there were some concerns mentioned as well. The main reason for caution mentioned though was that of improving processes related to the pace and the contents of the further agreements and the assignment documents. Currently, these documents are produced serially. Engineering firms feel though that this does not fulfil the potential: "they have to come with clusters of objects because what we have so far is the further agreement for one object. We promised that we will utilise uniformity between objects by developing smart things to do".
The engineering firms suggest that they should be involved more in drawing up the content of the assignment documents related to the further agreement. "Don't start by describing everything you want on paper and then sealing it up before handing it over. Take us into your challenge and we will make your challenge our challenge. If we can go there, then you have a much more effective process on the front end."

This concern would however not be enough to stop using this approach. The main reason why this is much more preferable for the client and the engineering firms is that only is one tender under competition at the start and no more after that for at least six years. One contract manager for instance mentioned he really liked the fact that when he receives a quote for a further agreement, he likes the fact that he can openly discuss this quote with this engineering firm. Someone from the engineering firms even mentioned that he felt as if RWS finally "did not think about collaborating with the market but thought with the market about collaboration".

15. Validation and discussion session

In order to analyse the findings from the interviews as described in chapter 13 further, a validation session was organised. This session had three goals:
- present the findings as presented in chapter 13,
- validate these findings to find out if things were interpreted differently, and
- have a discussion.

The findings were presented using the same three themes that are used in chapter 13, the programmatic approach, knowledge management, and looking forward. After a short recap of what the findings were for each theme, a discussion took place. In order to again have a well substantiated analysis, the principle of stratified sampling was used (figure XX). Eventually, 5 professionals were present both from the engineering firms and from RWS. Their functions ranged from junior engineer to senior engineer, and from technical manager to portfolio manager.

Programmatic approach

First, the identified goals for the 'bureau herberekeningen' were discussed. As mentioned in 13.1, one of the interviewees questioned the lumpsum remuneration for the concrete bridges. It stated that the goal for more efficiency hinders the goal for good knowledge management here because lumpsum incentivise to do as little as possible to make more profit. This would result in not spending time on knowledge sharing.

This statement came as surprising with some of the attendees. Someone from RWS mentioned that when you want to work faster, you first have to take a moment to think about how you will work smarter: "When I worked at an engineering firm, I never did two things the same. I made an excel sheet or a rapport and used that again for a new tender. And that might cost me 20% more time to develop, but then I had something that I could do much faster next time or just do according to that template". He stated that RWS should be willing to pay for that extra time to make sure engineering firms don't just blindly work harder instead of smarter. "Because then we won't make it".

One of the senior engineers from the engineering firms reacted here that if objects are similar, you can do something with that. "Can I parameterise one, speed it up a bit, so that the investment repays itself? We don't know that now. We now have the assignment for one bridge. Then you don't know where it will go or whether a lot of things you will come up with will ultimately pay for itself. For a lump sum assignment that of course is something". "We don't have to make ridiculous profits, but you should be able to do these types of projects for a fair price".

Collaboration days

It should be stated here that between the interviews and this validation session, the first collaboration days took place. Therefore, it was discussed here if the expectations as identified in 13.1. are actually met.

For concrete bridges, there have already been two knowledge sharing sessions. At the first one, TNO and one engineering firm with experience shared with the rest the background of the calculation method used for viaducts with half-joints. Especially what was done before and why, to at least share knowledge on where things are now. And for the second presentation, this engineering firm shared what they came across when they recalculated concrete box

girder bridges in the past. This would then allow for other engineering firms to use that knowledge for the upcoming further agreements.

As for the timing of these first presentations, it was not seen as necessary for them to take place earlier. Because the further agreements and the demand specifications were coming along slowly, one could have argued to have these presentations earlier. That would then allow to keep personnel invested and to already share experiences from other projects. This was however not seen as such because since you're working on it now, things will be more relevant, so I think it's fine the way things are going now".

Someone from Rijkswaterstaat who was sceptical at first even mentioned that there "really is a very dynamic atmosphere and you can just go up to someone and have a talk". "That at least worked well". This confirms the positive expectations from the others in 13.1. This scepticism was related to getting people to come to Utrecht, but this was again refuted by someone from an engineering firm: "at an engineering firm, many people do not always work in the same place as standard, they work in different places anyway. So that is not really a different challenge than within other projects".

It was also agreed here that it should really be possible and that it is really important to be able to walk up to someone and ask them a question or have a conversation. "That is really the added value for such a day". It should thus be prevented that someone is occupied with meetings all day. But so far, the collaboration day worked well, and the experiences were positive. "If you don't go into it with a positive swing, it's not going to happen".

Relevant knowledge

When the results were presented on what was identified as relevant knowledge, i.e. methodology and insights (sub-chapter 13.2.), someone from RWS mentioned that he thought that it should not just be knowledge management, but it should be aimed at knowledge development as well. "Because we know have to recalculate 400 bridges, but up next there will be 40.000 bridges in the Netherlands, so I think it should go faster through automating".

A senior technical manager however stated that in the end we might be able to do less, and "we now do quite a lot of things for each object that we are now doing in search of certainty". "That we will decide that we just don't do things because we have seen with another bridge that it makes no sense". "That we will say yes, we can calculate that, but we already know what will be the result. So, let's not do that sum in this case".

Sharing knowledge through checking each other's calculations

It became clear from the interviews that checking each other's work creates a practical opportunity for sharing knowledge and getting insight into what the other engineering firm is doing and why. The first topic for discussion here was the right level of involvement of the individual that does the checking. For steel bridges for instance, the engineering firm that checks the work is even present at all the technical meetings as well.

This seems to work well for the larger and more complex steel bridges. It is mentioned that between two engineering firms involved, there are already Excel sheets being exchanged for the archive studies in order for the method to be checked. "There were already discussions about whether it should be done one way or the other. So, we have already consulted with the other engineering firm and also communicated this with Rijkswaterstaat: We think this is the best way, so we will both do it this way".

It was mentioned for concrete however by one of the engineers that it probably would not be necessary to have the assessor being present at all the technical meetings because there are less likely to be discussions about the methods used

The junior engineer present noted that if knowledge is indeed being shared by engineering firms through these assessments, that the person assessing should then also communicate these lessons learned back to the other engineers in their organisation. That the team working on these recalculations also meets once every week or every two weeks.

There was one risk though that was mentioned in an exploratory conversation and was presented here to discuss. This was the risk that when an assessor could become too involved in the discussions about the methodology in the technical meetings and would therefore no longer be objective enough. A technical manager for an engineering firm answered here that this would not be a risk because with steel bridges, the methodology is discussed and agreed upon at the start of the recalculations. This means that you're not testing the quality of the work at the end, but if the agreed upon methodology is used along the way.

Furthermore, the assessing firm is also doing shadow calculations. This means that the assessing firm does a slightly simplified calculation alongside the engineering firm that is recalculating the bridge. This also has to be done alongside the original calculation because if there were to be a discussion about a certain topic than it cannot be the case that the assessing firm is still weeks behind on the main recalculation with their shadow calculation. Time would then be wasted if they had to catch up.

It was interesting that this topic of shadow calculations became knowledge shared because the technical manager from the moveable bridges that was present was not aware that this methodology was being used for steel bridges. This showed that these type of discussions on what methods should be used and why can really benefit sharing knowledge.

Finally, an important condition for carrying out these assessments successfully is that the parties involved should check each other the way they want to be tested themselves. This entails giving constructive criticism and civilised interactions. Someone from RWS then suggested to take this statement and think of it a little more broadly: "treat others as you would like to be treated yourself". "Because when I sometimes see a letter going out, I think guys, that's not a letter you should be writing".

Challenges when looking forward

When the results regarding the challenges were presented, the first response was that they were a bit negative. It was mentioned that the challenges as shown in figure 14.1 should be reformulated and turned around, as shown in the figure below.

Figure 15.1: The challenges turned around
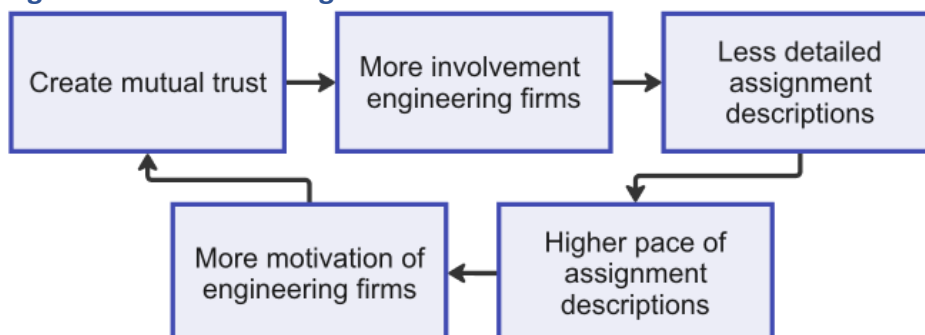
When one takes the challenges identified from the interviews and turns them around, as was suggested in the discussion session, the following positive loop arises

It was also mentioned here that creating less detailed assignment descriptions was already a goal for the moveable bridges. The technical manager for the moveable bridges from RWS present mentioned though that this "wasn't completely successful right away. We have now made the assignment specifications more detailed, but we will succeed in the future. I am convinced of that". It was explained that this was because it takes some getting used to it now. The portfolio manager from RWS even mentioned that in the future, they will tender so many bridges that there is no other option than to have less detailed assignment descriptions.

Connected to this level of detail is also the slower than intended pace at which the assignment details per bridge are handed over to the engineering firms. The people present from RWS recognised this as well. This was however followed by the warning that "a kind of rush then comes over it, while in the beginning we have to put haste in second place and put knowledge and things like that first".

Final remarks

Overall, the people present seemed to overall recognise what was identified from the interviews. There were some final remarks shared as well.

First, it was shared by a senior engineer that he really felt that this is a unique chance and that it is also a necessary to tackle this large challenge for the Netherlands as a whole to make the Netherlands demonstrably safe. He felt that if it will not be done like this, there will be an escalation in time and costs.

Another addition was related to the notion of trust by the client. "That trust can only come if you do that validation and verification, you shouldn't stop that". This underlines the assumption that trust must be earned and that it can be done with less control over time.

Finally, it was mentioned that it should not be forgotten to celebrate the successes of the 'bureau herberekeningen' as well

16. Conclusions from the empirical research

This empirical study considered a framework agreement for the recalculation of bridges of which the description is given in chapter 11. The answers identified from the empirical research for the two sub-questions are presented here.

2. What are the most relevant challenges related to knowledge management when considering a replacement- and renovation programme?

All and all, it seems that the main challenge is related to collaboration and communication. This was neatly summarised in the remark that the most challenging thing is that the client and the engineering firms together indeed become the 'bureau herberekeningen'. It is the lack of willingness to collaborate, to share and to listen that can create challenges. This lack can either be consciously and unconsciously because people can purposely hinder collaboration or knowledge sharing, or they can simply not be used to it yet.

One organisational aspect that can challenge this collaboration and knowledge management is that the 'bureau herberekeningen' is seen as something alongside the framework agreement. This can have the result that the objectives of knowledge management will become secondary to the project goals of delivering quickly. Especially when something goes wrong, and haste takes over the priority. However, it might be these moments when something does go wrong that there is the need to take a break, assess what has happened, identify lessons learned, and share knowledge.

Another challenge that can hinder the willingness to contribute to collaboration and knowledge management is the lumpsum remuneration for concrete bridges. Lumpsum remuneration can create a negative incentive for engineering firms because they earn the most when they do as little as possible. This might decrease the willingness to fully contribute to knowledge sharing and collaboration because that will only cost more time and money.

The collaboration days were mainly assessed as positive. A challenge however might be to get people there. Especially those who at first might not be interested at meeting on location in Utrecht. This can be especially challenging at the beginning when the collaboration days are not a standard practice yet. It was expected though that once people will be there, they will see the advantages and the opportunities to learn from others.

Another challenge related to these days is that they must be organised usefully. There should be room for regular work, meetings, presentations and informal get-togethers. However, it is needed to be cautious that one of these activities leaves no more room for the others. That people are not available to answer questions because they are in meetings all day. Or that people do not come to Utrecht because they only have to do their regular work, and they can do that somewhere else as well.

Another challenge here is getting people to know each other. When people don't know each other they for instance might be more reluctant to just walk up to someone and approach someone at the collaboration days to ask a question or ask for help. This could then hinder knowledge sharing and collaboration.

One challenge mentioned by someone from Rijkswaterstaat was that people are taken out of their usual workplace when they have to go to Utrecht, but this challenge was debunked by the engineering firms. They are already used to working on different locations.

The challenges identified for the relations within the framework agreement are mostly considered to be between the client and the engineering firms. Despite someone from Rijkswaterstaat expressing the realisation that the client has to be willing to listen, there is a feeling from the engineering firms that this is not the case. The engineering firms mention that there seems to be a lack of trust. This would have resulted in the assignment descriptions to be too extensive and unnecessarily detailed because RWS wants to stay in control. This can create a gap between the client and the engineering firms that hinders knowledge sharing.

Despite competition not being assessed as a big challenge, the main condition given for competition and the relation between engineering firms not to become a challenge is reciprocity. This means that there is a mutual exchange of knowledge from which all parties involved benefit. The reason given why this could be a challenge is when there might be engineering firms with noticeably less experiences or knowledge than others. This could then result in friction when people feel that there is a skewed balance in the knowledge shared. Others however contradict this challenge because there should be no sense of competition because the bridges have already been divided.

Also related to the assessments of the recalculations among the engineering firms, openness and willingness to share can be a challenge. Also, the way these assessments are executed is a challenge. They must consider constructive criticism from which the engineering firms can learn. The interaction between the parties doing the assessments can become challenging when feedback and communication is non-constructive and judgemental.

The main challenge related to the motivation and pace is shown in figure 13.1. Not handing over the further agreements quickly enough, or not bundled, decreases the motivation of the engineering firms and thus the willingness to collaborate. This can be related then to knowledge management because it can decrease their willingness to share.

Also, when assignment details for bridges are only handed over one by one, there is no possibility to use insights, experiences, and available knowledge to look for relations between different bridges and projects. This means that it will become more difficult to use the available knowledge well.

3. *How do the roles and assumptions in the information and knowledge landscape influence the challenges in a programmatic approach?*

Overall, not many differences were identified between the assumptions of the different parties involved. The main difference that can be identified is that there are different opinions between engineering firms and Rijkswaterstaat on what is relevant. This is probably related to the biases described in chapter 12.1. Because Rijkswaterstaat is the public client and the asset manager of these bridges, they feel responsible. This might result in them having the idea that they need to know everything about their bridges. This perhaps also is what resulted in the remark one of the engineers made that Rijkswaterstaat has the idea that they know best. Because they have the feeling that they need to know what is best for their bridges.

The engineering firms seemed to be more lenient in what is relevant. Not everything seems to be as relevant and if the result is correct, then it should not be necessary to extensively go through all of the methods and understand why everything is exactly the way it is.

IV.   Conclusion and discussion

This section presents the final conclusion and discussion

This section consists of four parts:

Figure IV.1: The Spijkenisserbrug

One of the fixed steel bridges that have been identified by Rijkswaterstaat to be recalculated is the Spijkenisserbrug near Spijkenisse in the Netherlands. Photo: Rijkswaterstaat

17. Conclusions

This chapter presents the final conclusions from this research. This is done with the answers to the sub-questions from the literature study that are given in chapter 10 and from the empirical study which are given in chapter 15.

The research question that is answered here is:

How can we overcome challenges related to knowledge management in an inter-organisational programmatic approach for the replacement- and renovation task of bridges in the Netherlands?

Three themes seem to be most relevant to the challenges mentioned: commitment, willingness, and relations. For instance, the commitment to the programme goals or the commitment for the collaboration days. But also, for example the willingness to share knowledge and the willingness to listen. And finally, the relations between the different organisations involved as well as the relations between the bridges.

First, the main challenge is not one that is related to knowledge management. The main challenge is related to the commitment to get the programme, i.e. framework agreement and the 'bureau herberekeningen', in full swing. Despite the great overall enthusiasm of the interviewees, there seems to be a lack of truly embracing this new possibility for collaboration. All parties seem to advocate to change the way the work is organised but there does not seem to be enough action to really make changes.

Taking the detailed assignment descriptions for instance. Apart from them taking longer than favourable to draw up, renovation projects are uncertain by nature and there is an urgency to renovate bridges in the Netherlands. There is no room for falling back on bureaucratic habits of prescribing everything in detailed further agreements. This takes more time than necessary and has no benefits because it is likely that changes will occur during a project. Especially for the longer more complex projects. This challenge as described in figure 14.1 mostly seems to take place at the programme level and within the relation between the client and the engineering firms.

Because these extensive further agreements take longer to draw up, the opportunity to compare a larger number of projects decreases as well. There are benefits related to relevance of knowledge and innovation between different projects that will be lost when there aren't enough projects to compare at the front end. When one can compare multiple projects at the front end of a programme, opportunities or challenges that relate to multiple projects might already be identified.

To overcome this challenge, a first step is to decrease the detailed descriptions of the further agreements. This does not mean that they should be gone all together but to make them less extensive. This needs trust between the client and the engineering firms that both parties understand what needs to be done. It is then needed to communicate where the assignment comes from and to accept uncertainty. Part of this is rephrasing the projects so that they are not just the client's problem, but that the engineering firm are taken along in the assignments. In order to learn best from the projects, one does, it is necessary to do many projects. Because if the pace of the further agreements remains similar to what it was in the first half year of the framework agreement, then it is not likely that the bureau herberekeningen will be as successful as it could have been.

Trust was mentioned as an important condition for the 'bureau herberekeningen' to be successful. A social mitigation that can take away some of the fear that organisations cannot be trusted is that of the group dynamic. It would for instance stand out if one engineering firm were to bill an unrealistic high number of hours worked in comparison to other engineering firms.

Another reason for commercial engineering firms to be committed and willing to share and cooperate is the certainty of work. The idea that it is certain that one can recalculate a next bridge after the one you're doing now can decrease the sense of competition. It is a certain guarantee of work without frequent tenders and thus a certain turnover that is very appealing. Expressing this certainty can also be used as mitigation when there is a lack of reciprocity. Engineering firms can be more willing to be open to other engineering firms on how they work if the client wishes so, as long as they receive something in return: i.e., a certainty of getting multiple projects. However, the client should then really act to create this certainty of work in order for the commercial parties to be willing and committed to cooperate and contribute.

Something that can be seen as a solution for willingness and relations between organisations is mentioned is proximity. In the 'bureau herberekeningen' this is realised with the collaboration days, i.e., bringing people from different organisations closer together. It is however still necessary for these days to manage relations strategically to secure optimal outcomes. For instance, through organising meetings in Utrecht so that people are somewhat obliged to be there. Or through organising informal get-togethers to have people getting to know each other better.

A practical solution to stimulate the programme objective of knowledge sharing and collaboration is something that can be taken from the 'bureau herberekeningen': the recalculation assessments where engineering firms have to check each other's recalculations. This is a practical activity that connects the recalculation projects to the objective of knowledge sharing and collaboration between the engineering firms. Engineering firms have to get involved into what the other firm is doing, and they must present their work in order for it to be assessed. This can somewhat circumvent a lack of willingness.
Also, if project objectives were to become a priority, and knowledge management gets sidetracked, the assessments are still an obligatory part of the contracted work. Knowledge sharing and retrieving can still take place as long as these assessments are then also considered as knowledge sharing session where questions can be asked, and discussions can be had. One might even consider them to be project evaluations.

And finally, it is important for knowledge management to understand relations between organisations as well as the bridges. It is important that knowledge management is related to the project activities. It for instance relies on:
- How different bridges relate to each other; is there something that bridges have in common from that requires attention?
- How experiences relate; does the situation now relate to something encountered in the past? Or did something new occur that we did not encounter before; do we need to develop something new to handle this new situation?
- How methods relate; do different organisations approach a project similarly or do their methods differ?

All in all, the 'bureau herberekeningen' is a unique opportunity in the Netherlands to be able to carry out the recalculations and the objective of knowledge management efficiently, effectively and successfully. Commitment and mutual trust are however needed from all parties involved to really capitalise on this opportunity. Because the way the organisation of the framework agreement has been thought out can really contribute to a successful programmatic approach. The inter-organisational assessments, the collaboration days and the framework agreement create opportunities to truly collaborate and share knowledge. Only when this large renovation task is tackled together, the Dutch bridges can be kept safe.

18. Discussion

This chapter discusses the meaning and relevance of the research results. This is done by considering the validity, result interpretation, and limitation discussion.

Validity

The first discussion point for validity is more of a political subject but one that is perhaps the basis of collaboration between public and private parties, nevertheless. This type of inter-organisational programmatic collaboration that this research is based upon still depends on a public client outsourcing work to a commercial organisation. One might argue that

1. if the engineering work related to infrastructure is of such importance,
2. if interface management between different organisations is difficult, and
3. if excessive transaction costs are a problem,

it might be a better solution to organise this type of engineering work inhouse in the first place. It was also mentioned during an interview that the specialists from Rijkswaterstaat also preferred the engineers being their colleagues and being in Utrecht every day.

One argument that might be relevant here on why this is not the case is that by outsourcing the work, one might also outsource the discussion of how the work should be organised.

Regarding the concept of external validity, the empirical results might not be generalisable for every other country and every other organisation. The reason for this is that organisational culture and interorganisational relations play a big part here. Lycett (2004) adds to this that there is no standard approach to programme management. Some of the specific challenges found here might not be relevant to other organisations or organisations might have other specific challenges that were not found here. The degree of competition between two companies for example might be much more of an issue in another country where there are different organisational or national cultures. Willingness to share knowledge for instance can be a challenge. If there is a lack of willingness, then there is no foundation on which the solutions can be build.

The theoretical framework in chapter 10 can be relevant to other programmes. Only the interpretation or the extent of importance of the topics mentioned might differ in another context. Proximity might for instance not be a challenge when everybody involved in a programme works in the same office building.

One aspect that also influences this research but was not included is the departure of staff. Relevance of knowledge can be subjective and tacit knowledge is within the heads of individuals. This means that a change in the people involved can influence knowledge management. Despite it not being mentioned explicitly in this research, some of the aspects can help to cope with a change of people. First, storing explicit knowledge can help to prevent a certain loss of knowledge. Unfortunately, not all knowledge can be stored, and some things will be lost. Flexibility of programmes and adaptation is another aspect that might catch some of the disadvantages of individuals leaving. The organisation might be mature and flexible enough to accommodate this change.

Interpreting results

There is one result that stood out that was not expected at first. At first it was expected that the relation between different commercial parties would be challenging. It was expected that the willingness to share knowledge between these companies would be a sensitive issue. This

however did not seem to be the case. All interviewees from commercial parties seemed very willing to share knowledge. It is however still an expectation at this point in time and it might still turn out to be an issue later on. But still, it was surprising that the relationship between the client and the engineering firms seems to be a bigger challenge at this moment.

An explanation why competition does not seem to be much of an issue is the understanding between engineering firms that there simply is too much work for only one single company. Engineering firms do not have to compete for a piece of the pie for work related to renovations because the pie is large enough for everyone.
Another reason might be that there are no more tenders under competition after the framework agreement has been signed. This means that engineering firms are more willing to share and cooperate because they have already been awarded their own set of bridges.

When comparing the results of this research with the theoretical framework, some similarities and differences become apparent.

Similarities are as follows:
- The balance between the project goals and the programme objectives is something that is mentioned to be a challenge in literature. Interestingly, this now also seems to be the case at the 'bureau herberekeningen'. Due to a certain feeling of haste, the projects become the priority while programme related activities now take place in the background.
- The notion that a difference in knowledge and experience between two parties can be seen as a challenge for collaboration is mentioned both in theory and in practice.
- Proximity is considered important in theory and in practice. In the 'bureau herberekeningen' it are the collaboration days that provide proximity.
- Both from literature and practice, a lack of trust is seen as an important challenge to overcome. It seems to be the inappropriate degree of control and detail that is the result of a lack of trust. In the 'bureau herberekeningen' this was described as the further agreements being unnecessarily detailed and extensive.

Differences however are:
- Adaptation and flexibility and being able to cope with change were not explicitly considered in practice. In literature, these aspects are seen as important properties of a programme.
- Knowledge storage is apart from a statement in the collaboration covenant not really involved in practice. It did not really become apparent that steps were undertaken to formalise a knowledge database.
- Connection to context was not explicitly considered in the 'bureau herberekeningen'. For instance, the consideration to share knowledge with construction companies. Perhaps new or different insights come to light when contractors are given insight in what is going on. This can then already be some sort of interface management for when a bridge needs to be renovated

A new insight and an interesting difference that has been identified in this research is an addition to the theory of knowledge management. In literature it is mentioned mostly that an open culture can improve knowledge sharing. It is true that this indeed is a requirement, but one can imagine that knowledge management might not automatically take place from one day to the next when this is the case. Apart from enthusiasm perhaps, there can still be the

needs for a reason to undertake knowledge management and to get together and share knowledge. It is then necessary to implement formalised activities that stimulate knowledge management. This can then create an organisational culture in which knowledge management is a standard practice.

Activities that can be seen as an example here are project evaluations, where project teams get together, discuss experiences and improvements, and take this identified knowledge with them. There are however still drawbacks with activities such as project evaluations or knowledge sharing sessions such as presentations. Both activities have a certain non-binding characteristics. They are not really a standard part of projects in practice due to a certain hectic that resides in a project when it is in full swing and has to deliver results. These knowledge management activities will then likely end on the background or not take place.

It is thus desirable that knowledge management activities are integrated into the standard project practices. That is something that might now be happening at the 'bureau herberekeningen'. The technical assessments of the deliverables have been moved to the project level, i.e. between different project teams, instead of between the project team and the client or some higher management (figure 18.1). This results in knowledge being shared between related projects on the project level directly between the people working on projects.

Figure 18.1: Shifting technical assessments to improve knowledge sharing

This figure shows how the flow of knowledge will change when the execution of the technical assessments is shifted as well. These checks are then not only done by the client, the quality control department or the management team but by a different project team. This changes the flow of knowledge from a one-way stream (blue arrow) to a two-way knowledge exchange (green arrow). It can still be necessary for the client, the quality control department or the management team to assess the work afterwards, but large mistakes or misconceptions might then already have been found by the other project team.

The benefits of using a technical assessment- or validation activity between different project teams or different commercial organisations within a programme as a knowledge sharing event are then:

- Knowledge identification, sharing, and retrieving becomes part of an activity that is more of a standard practice in project management, i.e. quality control. It can therefore become part of the 'regular' work.
- It allows for an adjustable degree of involvement. There can be an exchange of codified explicit knowledge through reports for example for simpler and smaller projects. There can

however also be frequent meetings between the different project teams where socialisation of tacit knowledge takes place through discussions on methodologies.

- Project teams really have to show what they are working on and how they do their work. It becomes more difficult to hold up a façade where only the successes are presented and not the challenges or difficulties.
- It moves the process of technical assessments to the project level within a programme. If the projects are outsourced to another party, the client can suffice with a smaller number of in-house experts or does not have to outsource this work to yet another party.
- More content and work related topics are discussed at the project level instead of managerial topics such as time, money, and personnel.

This does not mean that there should be no more technical assessments by the client for instance. A client might still want to do their own assessment. The difference is though that the other project team might already have identified some points of attention before the clients receives the results.

This suggestion is however not a complete solution for a knowledge management system. It is still needed to store this knowledge in a codified manner similarly if it were a normal evaluation.

Considering the literature and the theoretical framework of chapter 10, the notion of 'involvement' could then be added as an important property for knowledge management in an inter-organisational programme.

Discussing limitations

Several limitations can be considered for the results of this research. First, the number of people from different organisations related to the framework agreement interviewed could have been more extensive. This does not mean the quality of the data retrieved from the interviews was not sufficient, but perhaps more of a generalisation could have been identified if more interviews were held. Also, not all parties involved in the 'bureau herberekeningen were involved in this research.

Another limitation for this research was that when this research took place, the 'bureau herberekeningen' was not at full swing yet. The framework agreement had only just been signed and the work had not yet really taken place. This means that the results presented in this research are mainly expectations. When one were to do a similar research again, it would be advisable to do the research when the programme is in full swing. Either to see if the expectations presented here still hold or to see if there are significant differences.

19. Recommendations for practitioners

The first recommendation relates to the identified challenges that resulted in a loop. It is recommended here to try to turn the loop of figure 13.1 around and focus on the topics shown in figure 14.1. Considering the broadly supported notion that more needs to be done in less time by fewer people, reducing the level of detail and the extensiveness of the assignment details is a good first step to speed up the rate of the further agreements.

By speeding up the rate at which the further agreements and the assignment details are handed over to the engineering firms, one can also make more advantage of the benefits of bundled projects. By handing over projects to the market one by one, points of interest might be missed that become apparent when one considers multiple bridges at the same time.

It can be expected that it is not possible to have them ready all at the same time. If this is the case, the advice then is to at least try to have smaller bundles of similar or related bridges ready together. These can then still be divided between different engineering firms because that might then only encourage them to go look at the knowledge and insights of others by asking questions. It should then also be encouraged by the programme manager to look for these relations between the different bridges, even if the further agreements are not ready yet. For instance, organise a knowledge sharing session in which the different bridges and initial insights are discussed between the engineering firms.

Despite it not being extensively dealt with in this research, a practical suggestion is to store knowledge explicitly in the form of calculation standards for situations that differ from the standards that are already there. If it turns out that there is some sort of 'golden standard' that entails steps that can't be captured well into standards, try to formulise some sort of handbook or best-practice manual.

Make good use of the chances there are when engineering firms have to check each other's work. Consider it not just as a quality check but approach it as a knowledge sharing and project evaluation activity as well.

Despite the recalculations not being yet completed, try to already look ahead. For the engineering firms this can relate to already considering ideas for strengthening or renovation when recalculating a bridge. For Rijkswaterstaat, try to consider possible programmes for the next phases. Is it a possibility there will be a 'bureau verstevigingen' (bureau for strengthening), or a 'bureau renovaties' (bureau for renovations)? How would these programs then relate to the current programme? How to get the insights from the recalculations and inspections to the engineers designing the renovations or the contractors who have to construct them? These are aspects that can already be considered to perhaps integrate these parties early on and manage interfaces.

The framework agreement has the characteristics of a programme and the programmatic approach, despite this not being explicitly the reasoning behind how it's organised as such. It seems that the 'bureau herberekeningen' has been added from the need to more efficiently recalculate and prioritise bridges. There are however more benefits to be achieved from trying to consider this framework agreement as a real programme. This can start by considering the 'bureau herberekeningen' as a true programme and perhaps even as a real organisation. Try to only call it the 'bureau herberekeningen' from now on. Try to really make it come alive under that name. Mention it as if it is a consortium of some sorts. Celebrate wins and create the bureau's organisational culture. This can help with familiarity, shorten the communication

channels between different engineers and engineering firms, which can improve communication, collaboration and knowledge sharing. Especially because smaller governments also have a lot of bridges that need to be recalculated and being able to provide a plug and play solution might be really valuable.

20. Suggestions for future research

Regarding future research, some suggestions are given here.

First, it might be interesting to do a similar research in another industry. Will these findings, challenges, and solutions still be relevant when they are tested outside of the infrastructure renovation context. Perhaps there then is less time pressure or a sense of urgency. How would that then influence the findings?

Also, regarding the 'bureau herberekeningen', it can be interesting to research again in five or six years if some of the expectations have really come true. How did the 'bureau herberekeningen' perform? Were the assessments really as beneficial for knowledge sharing as expected?

One could also research what the complications for a similar framework agreement or programme will be when it is organised for the next phases of the renovation task. Does anything change in the design phase or the execution phase? Is the collaboration different when construction companies are expected to collaborate? How do the interfaces with previous phases have an influence? Or what could be the implications for the programmatic approach when it would be organised for smaller public clients? How will this then be organised? Do they need to group their infrastructure?

Another interesting research topic would happen if you turn the tenders and the supply and demand 180 degrees around. Then it is not the public client that starts a programme and then writes a tender for commercial parties to place a bid, but it's a group of commercial parties, e.g. the 'bureau herberekeningen', that continuously works on projects to who the public clients can then 'bring' their bridges. This could especially be interesting for smaller public clients who might not have the people or knowledge to organise a tender themselves. What would then be the challenges legally, financially, organisationally? This idea was made apparent during the identification phase of this research. It has already been presented during some of the interviews and was mostly considered to be an interesting notion.

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A. Interview questions

This appendix gives the list of interview questions as that were used for this research. The reasoning behind these questions is explained in sub-chapter 13.2.

The programmatic approach

1. According to you and in your own words, what is the goal of the 'bureau herberekeningen'?

2. What do you think of meeting one day a week in Utrecht? Will this work?

3. How are the relations within the 'bureau herberekeningen'? Can a certain degree of partnership arise or will there still be a client-contractor-competitor relationship?

Knowledge management

4. What do you regard to be relevant knowledge and what knowledge do you want to receive from other organisations? E.g., experiences, insights, reports, data, methods, results, or something else?

5. Will competition between the different organisations become a challenge for sharing knowledge? To what extent are the engineering firms prepared to provide insight into what they do, how they do it, and what they know?

6. Will checking each other's work help to promote knowledge sharing by providing insight into each other's considerations and methodology? What would it take to facilitate this, e.g., level of insight, openness, willingness, or something else?

Looking forward at the 'bureau herberekeningen'

7. If you could mention one point, what might be the biggest challenge for the 'bureau herberekeningen'?

8. If it turns out that collaboration and knowledge sharing via a programmatic approach does not work as intended, is it still necessary to work with separate projects and tenders again?

B. Exploratory conversation data

The exploratory conversation data used for this research is restricted for the public version of this report and can be requested by the researcher.

C. Interview Data

The interview data used for this research is restricted for the public version of this report and can be requested by the researcher.

D. Validation session data

The validation session data used for this research is restricted for the public version of this report and can be requested by the researcher.