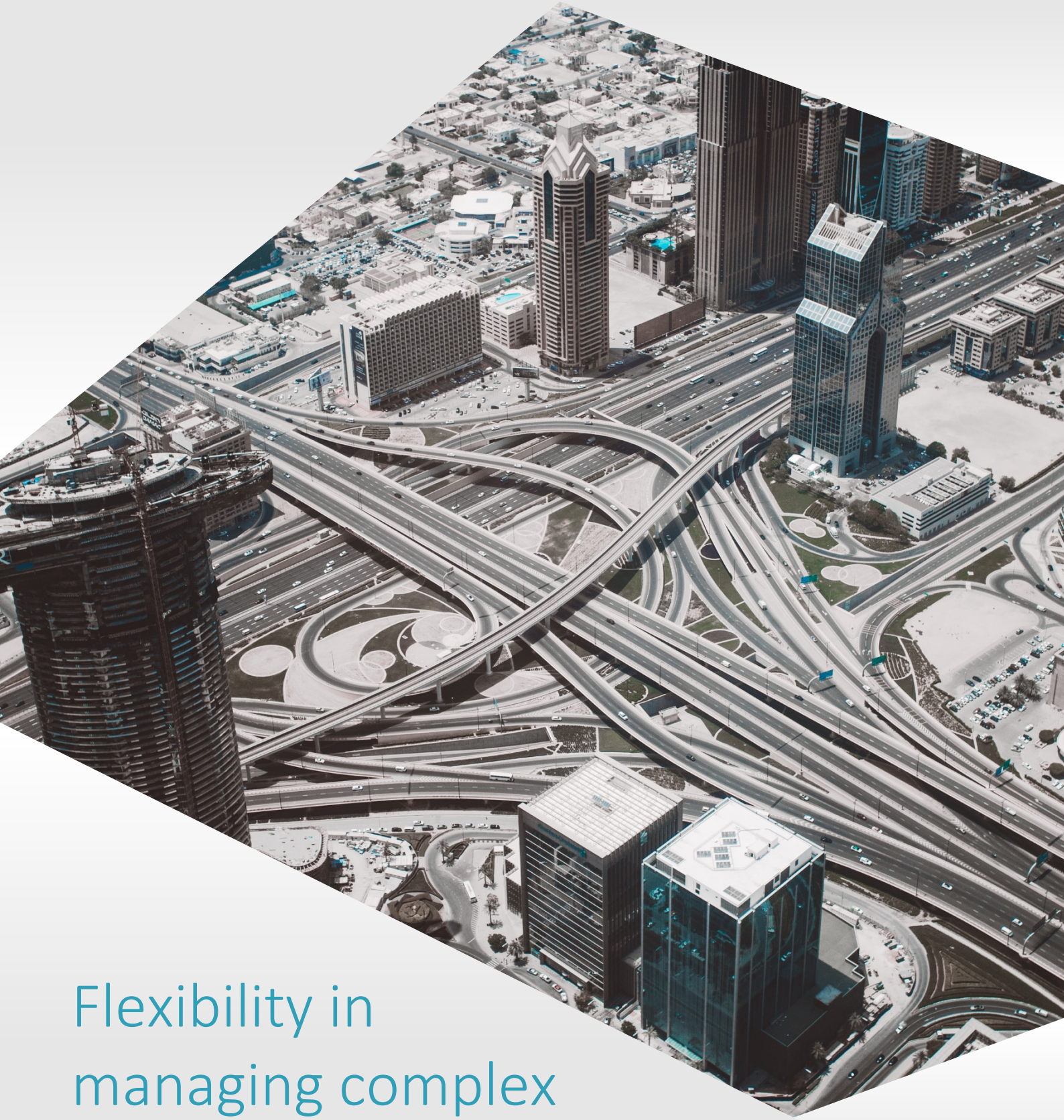

Flexibility in managing complex infrastructure projects

How flexibility enablers can facilitate the management of project complexity

Master thesis by Leonie Kostman

Thesis report

How can flexibility enablers facilitate the management of project complexity?

Explanatory qualitative research within the field of the construction sector and infrastructure projects.

By

Leonie Marlissa Kostman

to obtain the degree of Master of Science
at the Delft University of Technology

Student number:	4207971	
Project duration:	November 2020 – May 2021	
Thesis committee:	Prof. dr. H.L.M. Bakker	Chair
	Dr. ir. M.G.C. Bosch-Rekveldt	First supervisor
	Dr. ir. L.H.M.J. Lousberg	Second supervisor
	MSc M.M.M. Derks	External supervisor (Arcadis)

TU Delft

ARCADIS

Preface

This thesis is the proud result of more than six months of hard work. These months have been exciting, challenging, educational and have given me the energy to start working after this thesis. I would like to present to you my graduation thesis to conclude my master's degree in Construction Management and Engineering (CME) at the Delft University of Technology in collaboration with Arcadis.

This research's topic has intrigued me since the beginning of my master. Complexity and flexibility are topics that will never be 'solved' and depend on people, which makes it a fascinating topic for me. I like to think of how to improve working methods and to collaborate with others. During this research, I was fortunate to have the support of many different professionals from Arcadis. They have provided me with insightful information on encountered complexities and their knowledge and perception of flexibility, which allowed me to better understand coping with complexity by managing with more flexibility. In addition, my research was way more fun because I got the chance to interview and talk with various experienced, intelligent, helpful and fun people.

I would like to express my gratitude to everyone who has helped and supported me during the process of this thesis. Special thanks to the members of my graduation committee, Hans Bakker, Marian Bosch-Rekveldt and Louis Lousberg, who guided me through this new and challenging process. Also, I want to thank my colleagues of Arcadis and particularly Marly Derks for the time and effort you have dedicated to me and my research. Last, I want to thank my loved ones for their patience and for sharing happiness with me during this thesis and my study. The journey has been challenging, and I would not have been able to succeed without you!

The quote below hints at the essence of this thesis and the process of writing the thesis. Maybe this quote can even be a life lesson for everyone, personal and work-related. Especially during these extraordinary times, due to the covid virus, this mindset helped me seize opportunities and explore possibilities.

"The water of a river adapts to whatever route is available. Learn to shift with the changing times as you keep sight of where you are going."

Ed and Deb Shapiro, July 21, 2013

Leonie Kostman
Den Haag, May 2021

Executive summary

Research context

Nowadays, projects seem to become more complex and the project manager's ability to control projects decreases. Therefore, it is crucial to adapt project management to cope with the emerging complexity. Within the infrastructure sector, flexibility options are explored to deal with the increasing complexity. To grasp complexity, a selection of the Technical, Organisational and External (TOE) framework is developed (Bosch-Rekveldt et al., 2011). Research suggests that using flexibility enablers helps to cope with project complexities (Jalali Sohi, 2018). Flexibility enablers have been described as enablers that increase flexibility for project management. Eleven flexibility enablers have been selected from Jalali Sohi's category 'how', which have a proven relationship with project complexity. These flexibility enablers are studied to operationalise them and make them applicable for project managers.

Research question

In practice, there is a lack of knowledge of the adoption of flexibility enablers in managing complex infrastructure projects (Jalali Sohi, 2018). This research aims to map the complexities and explore the use of flexibility enablers to develop a strategy to make project management more flexible and to cope with project complexity. The research question is as follows:

| How can flexibility enablers facilitate the management of project complexity?

Case study

In this explanatory research, a case study has been done to explain the possibilities for flexibility enablers to cope with the found complexities. Four diverse cases in the infrastructure sector were selected based on three criteria. First, the selection is based on (1) an estimation of the management approach to have variety, more controlling and more flexible management approaches. Next, the selection was based on (2) being rail or road projects and (3) type of client for an equal division of project types. The case study consists of four projects with two interviewees each.

The case study consists of analyses of project documents and semi-structured interviews. The interviewees were asked to score a selection of project complexity elements and their project management approach in advance of the interview. The cases were analysed based on the selected project complexity elements, the project management approach and the use of flexibility (enablers) in the projects. To understand the perspectives of the interviewees on flexibility, flexibility word webs have been created during the interview. A cross-case analysis was performed to discover the relations between the subjects complexity, management approach and flexibility.

The results of the individual case study and the cross-case provided input for a proposal on how flexibility enablers facilitate the management of project complexity.

Results

In the cases, the applied flexibility for coping with project complexity was most often related to communication, interfaces and planning. The interviewees acknowledged the need for flexibility in project management.

From the selection of fifteen complexity elements and eleven flexibility enablers, it turned out that in the cases four complexity elements and seven flexibility enablers were most relevant for grasping and coping with project complexity. The four complexity elements are (1) 'dependencies between tasks', (2) 'involvement different technical disciplines', (3) 'interfaces between different disciplines' and (4) 'high project schedule drive'. Of the seven flexibility enablers, three enablers were perceived different by the interviewees. The three flexibility enablers explained to be different to allow for flexibility were (1) 'self-steering of the complete project team', (2) 'shared interface management' and (3) 'network structure rather than hierarchical structure'. These three enablers were explained to allow for more flexibility in the project under the condition that these elements require some structure. The four flexibility enablers supported and operationalised are (4) 'open information exchange among different groups', (5) 'trust among involved parties', (6) 'visualised project planning and progress' and (7) 'continuous learning'. These flexibility enablers were related to coping with

complexity in the cases and, except the enabler 'continuous learning', especially to the selected complexity elements. The element 'continuous learning' is explained to affect many of the complexity elements positively. However, no one-to-one relations have been found between the complexity elements and the flexibility enablers.

Flexible project management tool

The selection of complexity elements and flexibility enablers have been used to develop a flexible project management tool with relevant elements. The tool provides insights into the selected complexities, creates awareness on flexibility perspectives from the project team, allows to choose the operationalised flexibility enablers, and reflects on the changes made to keep improving. The tool is meant to be used throughout the project and supports incorporating flexibility to be a dynamic process. This is done by guiding the project manager through the process of determining the flexibility enablers for the project. The tool is not linked to one management method. The tool consists of four steps (see Figure 1):

1. Assessing the project complexity.
2. Mapping the perspectives of the project team on flexibility in the management of complex projects.
3. Selecting the flexibility enablers to apply.
4. Actively evaluating based on the process of coping with project complexity.

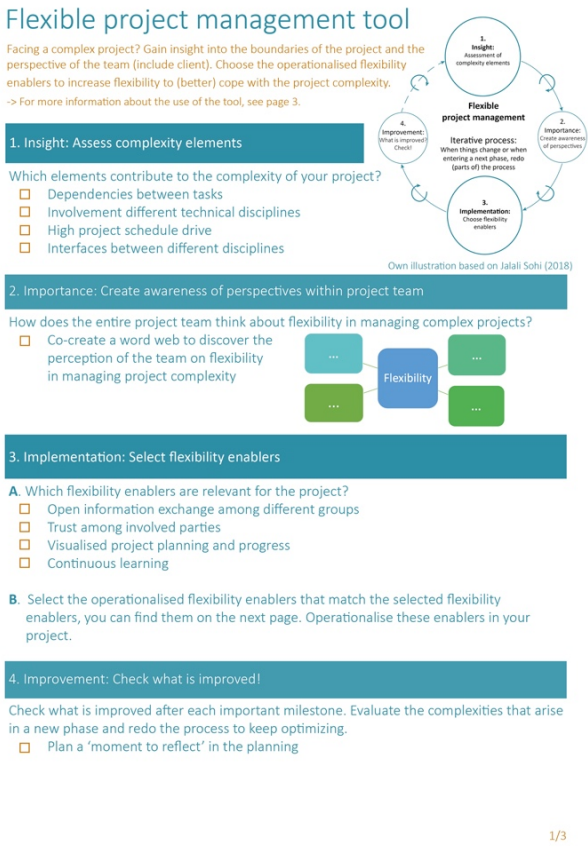

Figure 1 Flexible project management tool (page 1)

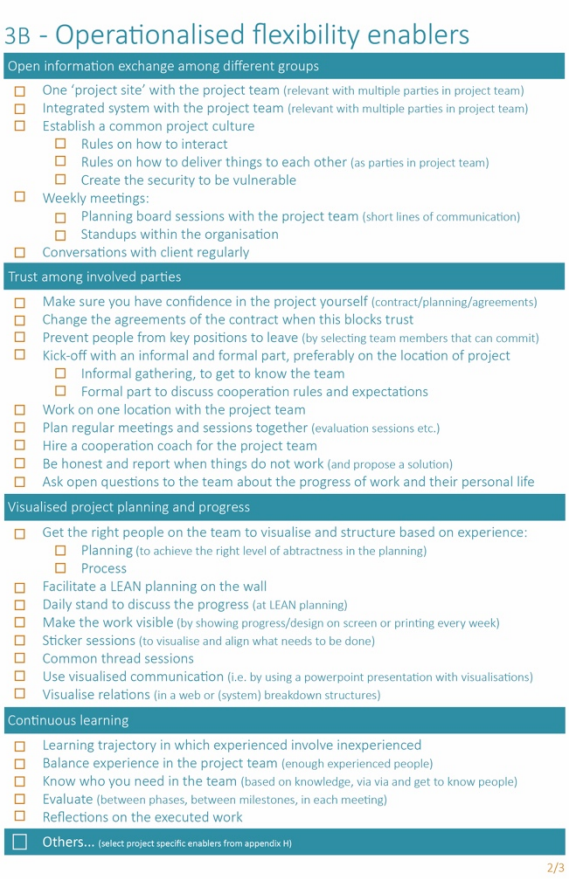

Figure 2 Flexible project management tool (page 2)

Tool evaluation

An expert session was held to evaluate the tool to enhance flexibility in project management. The consultation was performed with five experts in which feedback has been gathered through scores and a discussion. The tool has been evaluated on usability and form. Based on the expert meeting, three important points are included in the tool, (1) the notion for the involvement of the client on the first page (Figure 1), (2) the step with the checkbox of step four (Figure 1) and (3) the category 'others' added to the operationalised flexibility enablers to stimulate thinking of project-specific flexibility options.

The experts valued the flexible project management tool and the operationalised flexibility enablers. Resulting from the evaluation, awareness on the subject has been addressed to be of value. Flexibility should get more attention and understanding on the side of the client and contractor to better include flexibility in project management.

Final conclusion

The awareness of complexity and flexibility helps to cope with complex infrastructure projects. The developed tool for project management will help apply specific flexibility enablers to cope with relevant complexity elements.

Recommendation

The theoretical implication of this study is the contribution of the operationalisation of the selected flexibility enablers. This research can be used as starting point for further research on the practical implementation of flexibility enablers. In addition, the use of flexibility enablers can be further studied in combination with different aspects such as other complexity elements, client, tender, contract (forms) and this can be done in various organisations. Further research is recommended on the awareness and the adaptation possibilities for flexibility in project management within the infrastructure. The final important recommendation is to study the three flexibility enablers explained to be different by the interviewees and look at the differences in the project manager's perception versus the team members.

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Abbreviations

CAT	-	Complexity Assessment Tool
EIA	-	Environmental Impact Assessment (MER - Milieu Effect Rapport)
IMS	-	Integrated Master Schedule
MEAT	-	Most Economically Advantageous Tender
MIRT	-	Meerjarenprogramma Infrastructuur Ruimte en Transport (Multi-year program Infrastructure, Space and Transport)
OSB	-	Ontwerpsaneringsbesluit (draft remediation decision)
OTB	-	Ontwerp-Tracébesluit (design plan approval decision)
PDC	-	Plan, Design & Construct
PM	-	Project manager
PMI	-	Project Management Institute
PMP	-	Project Management Plan
SCB	-	Systeemgerichte contractbeheersing (System Engineering tool)
SSM	-	Soft System Methodology
TAW	-	The Arcadis Way
TOE	-	Technical, Organisational and External (complexity categories in TOE framework)

1 Introduction

This chapter is an introduction to the subject and the problem statement of this research. First, some context on the subject is given. Next, project management at Arcadis is introduced. Subsequently, the research problem is explained, resulting in the problem statement, leading to the objective and research questions. The chapter ends with an overview of the report.

1.1 Introduction to subject

Infrastructure projects are prone to delays and cost overruns (Eriksson et al., 2017). These delays and cost overruns are regularly the consequence of project complexities. Rapid changes in the environment, increased product complexity and increased time pressure are causes of this increased project complexity (Bakhshi et al., 2016; Bosch-Rekveldt et al., 2015; Williams, 2002), which results in these delays and cost overruns. Complexity is an often-discussed topic in literature, especially regarding coping with this complexity in the construction sector. Many construction projects are perceived as complex, dynamic phenomena in a complex and nonlinear setting (Wood & Gidado, 2008). As the complexity increases, the project manager's ability to control all aspects of the project decreases (Eriksson et al., 2017; Gransberg et al., 2013). To conclude, complexity is emerging and managing complex projects is not entirely straightforward.

Traditional project management is focused on control and is more suitable for relatively simple and straightforward projects, whereas complex projects need new types of project management practices (Eriksson et al., 2017; Gransberg et al., 2013; Koppenjan et al., 2011; Williams, 2005). Coping with the emerging complexity is not as easy as it might seem; many problems are observed in literature as well as in practice. Effective project management requires both a proactive and reactive strategy in dealing with unanticipated and challenging events. A key element of success is developing a learning culture, which permits flexibility within a systematic problem-solving approach (Walker & Loosemore, 2003). Jalali Sohi et al. (2017; 2019) state that "flexibility of how", which focuses on the project management processes, should be explored further.

Flexibility in management is emerging as a key strategy in response to the constantly changing competitive environment (Lim et al., 2007; Olsson, 2006). This research focuses on the operationalisation of this strategy to achieve more flexibility in project management. The goal of this research is to deploy flexibility enablers to manage complexities.

1.2 Project management at Arcadis

This research has been conducted at Arcadis, a global engineering and consultancy firm that wants to keep improving and dealing with the dynamics of today. The mission of Arcadis is "improving the quality of life", and its five core values are People First, Customer Success, Integrity, Collaboration and Sustainability (Arcadis NV, 2018). Within these core values, it is not just about profit but about the whole picture of delivering something of quality.

Based on the goal of this research, infrastructure projects in the Netherlands have been studied. The studied projects of Arcadis take place in the front-end phase. At Arcadis, this phase is divided into the planning phase, design phase and contract phase (see Figure 3). The front-end phase is chosen for its' room to manoeuvre; according to Project Management Institute (PMI), the most essential processes to develop a project are in the planning phases (front-end) of the project (PMI, 2013). The internal use of the word 'Project' at Arcadis refers to their part of the overall project, the assignment they got from the client. This project of Arcadis is almost always a subproject within the clients' project(s) from a broader perspective. The studied projects of Arcadis can be in any part of the front-end phase of a project.

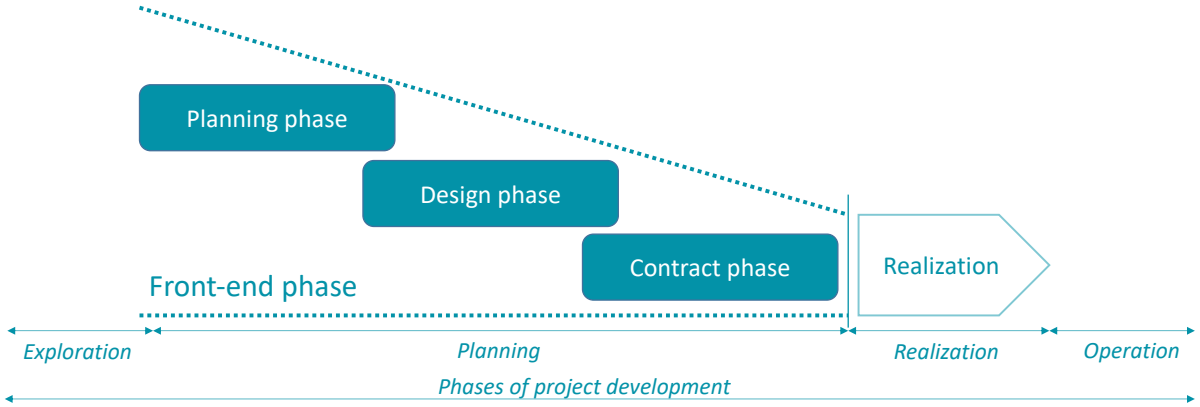


Figure 3 Front-end phase of a project with the specified phases by Arcadis and Koppenjan (2005)

Traditional project management method (controlling)

Traditional project management is also known as the waterfall method or controlling project management. Traditional project management involves completing the following five phases: initiation phase, planning phase (front-end phase in Figure 3), execution phase, monitoring and controlling and closing phase (PMI, 2013a). Project management involves fulfilling the pre-set demands. This is done by applying the knowledge areas of scope, time, cost, risk, quality, communication, procurement, human resources, stakeholders, and integration management. The processes and functions are applied sequentially throughout the various phases by the project manager and project team (PMI, 2013a). Controlling the project and sequential completion of tasks are essential characteristics of traditional project management.

The Arcadis Way

Arcadis prescribes one project management method for executing all the projects. This method is called The Arcadis Way (TAW) (see Figure 4). TAW is a representation of all procedures, templates, forms, checklists, and agreements. The core processes of TAW are presented in Figure 4. The process of 'Deliver to Result' (see Figure 5) is relevant for this research since it is the project part of the processes. Strategies can be applied to cope with complexities. In the 'Deliver to Result' process, flexibility could be relevant to cope with the complexities.

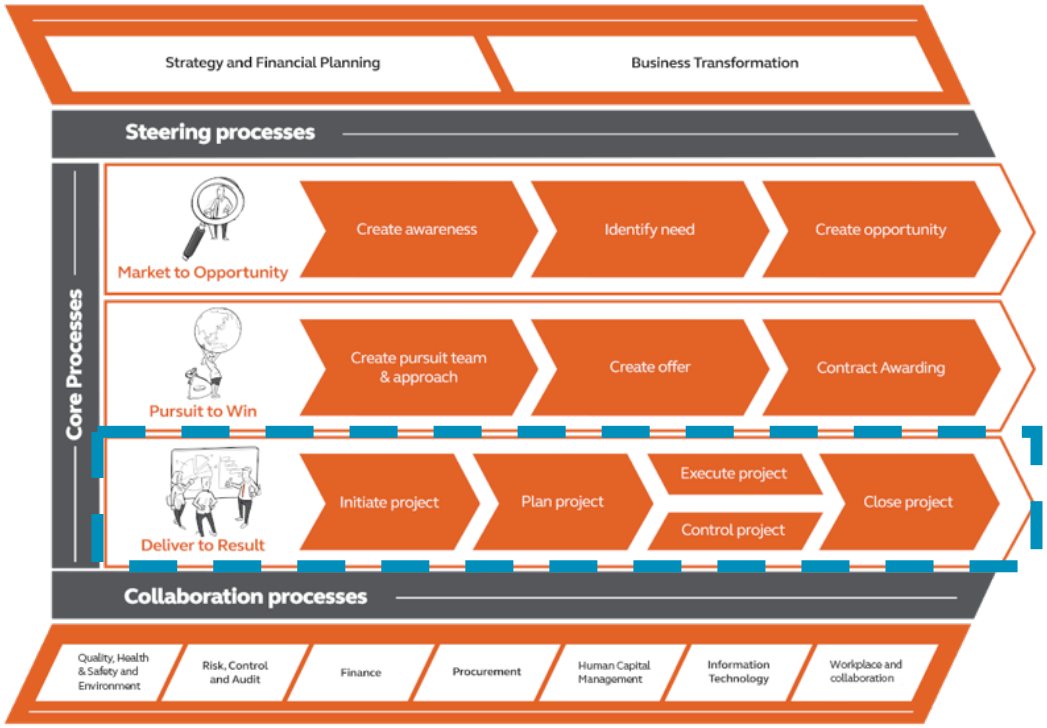


Figure 4 The Arcadis Way (TAW) Management system

The roadmap of Figure 5 zooms in on the core process 'Deliver to Result' of Figure 4 and shows the project management process of Arcadis within this phase. This roadmap is the method of how Arcadis executes the core process of 'Deliver to Result'. For each step in the figure, there is a further explanation and relevant templates are available. While the management method for this process (a roadmap of 'Deliver to Result') is leading, project managers have their own management approach in projects, providing opportunities for dealing with complexity.

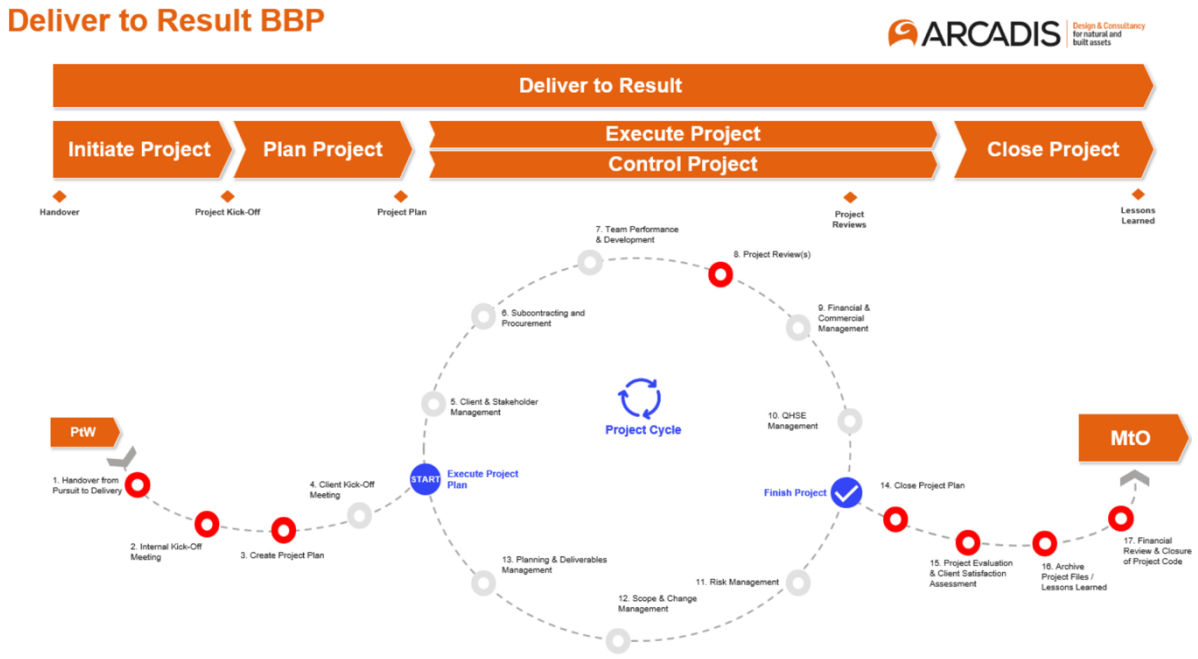


Figure 5 Roadmap with project process of Arcadis

1.3 Problem definition

Today's large infrastructure projects often face delays and cost overruns (Flyvbjerg, 2014). These delays and cost overruns are a well-known problem and only become more relevant due to increasing complexity, making projects even harder to manage within time and budget (Maylor & Turner, 2017). Until now, managing complex projects is an unsolved challenge (Jalali Sohi, 2018). The current management methods are not satisfactory anymore to manage complex projects. Flexible management methods are a proposed solution for complexity, especially in the IT sector. However, adopting a new method to deal with the complexities does not come naturally, and project managers and organizations do not prefer a new method (Jalali Sohi, 2018). Therefore, the complexities must be mapped, and management should be adapted accordingly. However, adapting the management accordingly to the complexities of a project is not as easy as it may sound.

In literature, it is found that 'the application of how to use flexibility to cope with complexity' is an underexposed subject (De Rezende et al., 2018; Jalali Sohi, 2018). Ford et al. (2002) state that the project complexities cannot be resolved adequately through improved control. Therefore, it should be explored how flexibility helps to cope with project complexities in practice. Consequently, Project Management Institute (2013) stated that complexity will not disappear and will only increase. Lessard et al. (2014) addresses coping with or accommodating complexity remains challenging, despite all the knowledge and intuition for the significance of complexity. Chester & Allenby (2019) mentioned that when it comes to infrastructure, the systems we have deployed and continue to maintain appear to be limited in adapting capabilities. This inability to adapt raises serious questions about their ability to provide services in the future with changing demands, population, climate, security challenges, and environmental conditions. De Rezende et al. (2018) has stated that due to the shift of focus to project adaptability, it is necessary to explore and develop capabilities to manage complex projects on the organization, team, and project level. In line with this view is Jalali Sohi et al. (2019), who advises further development of their research into how to embed the flexibility enablers into practice, considering the different perspectives and commonalities.

Challenge of managing project complexity from practice

Complex projects nowadays ask for a new approach with more possibilities to embrace complexity and dynamics. Within the management system TAW, Arcadis continuously looks for how they can better manage complexity throughout the projects.

Arcadis experienced that every project has its dynamics. Therefore, every project should be managed differently to respond to its unique properties. Significant differences experienced in complexity are, for example, in social complexity and technical complexity. Social complexity has to do with projects where social aspects are becoming more relevant and comprehensive, for example, stakeholders are more involved and demanding. Technical complexities still become more challenging and relevant, with densely built-up areas where projects must occur. This technical complexity has been widely touched upon in literature, while this remains a challenge in projects.

For a company to increase their competitive position, it is about combining all aspects, such as the quality aspects of the client and having the cheapest bid. To keep improving the effectiveness and efficiency, the management of projects needs to be able to adapt to the needs of the project. Within the set boundaries, the need for the ability to change during the project increases due to the dynamic environment.

Problem statement

Managing complex infrastructure projects is becoming more difficult due to increasing complexity, and there is no fit-for-purpose management method for organisations to adapt their management method. The literature describes adopting flexibility as a solution for coping with complexity. However, there is a knowledge gap on how to adopt flexibility in complex infrastructure projects for project managers to cope with the complexities.

1.4 Research objective

As illustrated in the previous section, dealing with complexity remains a challenge. Flexibility has been suggested as a solution, as opposed to control, for coping with project complexity and their management. Traditional management, which is often the starting point for managing projects, might be adapted with adding flexibility to cope with complexity. The goal of this research is to find out how project complexity can be managed using flexibility. Without adopting a new flexibility management method, coping with complexity should be possible by adding flexibility enablers to project management. In this research, the project complexities, management approaches and flexibility enablers are studied to develop a way to use flexibility enablers to cope with complexity. This leads to the following research objective:

Research objective

Examine how flexibility enablers can facilitate the management of project complexities within complex infrastructure projects.

1.5 Research questions

This paragraph describes the research questions based on the problem statement and research objective of the previous sections. First, the main research question is introduced. Next, the sub-questions are presented.

1.5.1 Main research question

From previous information, it appears that the 'how' is very important regarding flexibility enablers. Therefore, the main research question related to coping with complexity is as follows:

How can flexibility enablers facilitate the management of project complexity?

1.5.2 Sub-questions

To answer the main question, sub-questions have been composed. The sub-questions are drawn up to answer relevant parts to support the main question. Therefore, the sub-questions are be answered first, and subsequently, the main research question can be answered.

1. **What are the challenges in the management of complex infrastructure projects?**
   To obtain insight into the managerial practices and complexity, this question should be scrutinized by means of desk research.

2. **How is flexibility currently incorporated in the management of project complexity?**
   This sub-question aims to discover how managers use flexibility in their management approach to deal with complexity by means of a case study.

3. **What are the opportunities for incorporating flexibility in the management of project complexity?**
   To use flexibility in managerial practices, it is needed to identify the opportunities by finding the relations between the individual cases. With the complexities mapped, it is possible to identify where flexibility is needed. Exploring which relations between flexibility enablers and complexity elements can be found is part of this sub-question.

4. **How can complex projects become more flexible by applying flexibility enablers?**
   By having the information on complexity and opportunities established, this question can be clarified by developing and validating a practical tool. The flexibility enablers can be linked to the management practices and how they can be incorporated.

1.6 Report overview

The research can be divided into six parts: introduction and research design, literature, case study, the tool, expert session and conclusion (Figure 6). The introductory part consists of the chapter introduction and research design. In the chapter on literature, the background knowledge needed for this research is presented. The data required for this research is gathered via case studies. The case study method is explained, after which the cases are analysed individually, and after that, the cross-case analysis is presented including the results. Next, the results are presented employing a tool and the expert session to validate the tool. The conclusion is the final part of this research together with the discussion.

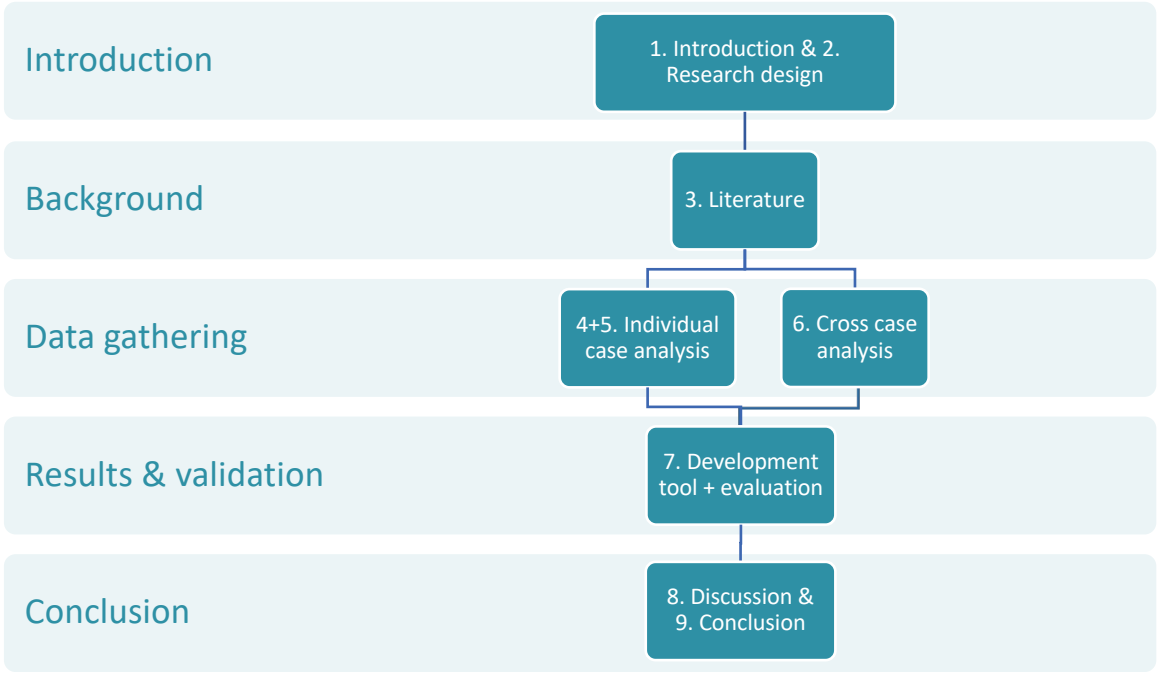


Figure 6 Report overview

2 Research design

This chapter describes the scope and strategy & methodologies.

2.1 Scope

This research focuses on infrastructure projects in the Netherlands. The context of the Netherlands has been used to limit cultural influences in the projects. The case study is performed on projects within Arcadis that (almost) have been completed and of which the project managers are still active within the company. This way, the most relevant information should be available. To conduct this research as a thesis, the study is limited to the front-end phase, as it is defined in the literature, or planning-, design- and contract- phase, as it is defined within Arcadis. This phase has been chosen because, in the front-end phase, the most important decisions are made, and the addressed complexities occur.

2.2 Strategy & methodologies

An explanatory case study with multiple cases was conducted to answer the 'how' research question. Explanatory research is an adequate strategy when clear ideas about the subject exist, but uncertainty about the correctness of these ideas is present (Van der Voordt, 1998). Qualitative data has been gathered through case studies to obtain specific information needed to achieve the depth of research and demonstrate the research's trustworthiness and credibility (Yin, 2011). Yin (2003) has described a case study as an appropriate method for research with a 'how' question about a contemporary set of events. It is tried to illuminate decisions and to find out why decisions were taken, how they were implemented and with what result (Schramm, 1971; Yin, 2014). Seawright and Gerring (2008) explain this research approach as the intensive analysis of a small number of cases, where a goal is to understand a larger class of similar cases. Yin (2018) also indicates a case study as one of the five suitable approaches to conduct explanatory research. Triangulation, in the form of a multiple-method approach, is applied to gather data and to be able to verify the data and avoid tunnel vision (Verschuren, 2003). The goal is to identify where and why problems arise and to investigate how flexibility enablers can deal with those problems. A qualitative-oriented approach has been applied through expert consultations to verify this obtained qualitative data within the company.

This research will explore the complexities and find how to cope with them within the circle of influence and the available academic knowledge. The case study fulfils the goals of this research because it focuses on understanding the dynamics present within single settings (Eisenhardt, 1989). By analysing documentation, assessing forms, and conducting interviews, the case study has been performed using different methods, pursuing their specific and common goal. The data obtained will be more compelling and robust with investigating multiple cases, and a comparison can be made. For this research, an individual case study and a cross-case study has been executed. This way, complexities and flexibilities can be assessed, and relations can be discovered by comparing the results of individual cases. In addition, an exploratory strategy is applied in the cross-case analysis to be able to explore the relations between the elements in this study.

To start, a literature study has been conducted to establish background knowledge. For the case study, project documents have been analysed to explore the complexities and flexibilities and interviews have been conducted to get insight into experiences from project managers in complex projects. Finally, qualitative research has been conducted by conducting an expert consultation within the company to improve and validate the recommendations of this research.

In Table 1, the overview of the strategy and goals can be found per sub-question. The literature study, case study, cross-case analysis and tool development all contribute to the sub-questions. With the evaluation by experts, which is part of sub-question four, the research conclusion can be drawn.

Table 1 Research questions coupled to method(s) and goals

	Strategy	Goal
SQ 1	Literature study (H3)	Developing a theoretical background for possible challenges in complex project management
SQ 2	Case study (H5)	Exploring the current use of flexibility in management
SQ 3	Cross-case study (H6)	Finding the possibilities for incorporating flexibility in project management
SQ 4	Development tool & expert consultation (H7)	Developing and validating a strategy for coping with project complexities
RQ	The result from all studies	Conclusion of the research

2.2.1 Literature study

To establish background knowledge in the field of this research, a literature study has been conducted. The literature review for a qualitative strategy is more selective as the purpose is to sharpen preliminary considerations (Yin, 2011). Therefore, the literature study focuses on the themes of Table 2.

Table 2 Literature review: context and selective

Literature background	
1. Creating context	2. Selective review
a. Complex infrastructure project	a. Difficulties in infrastructure projects due to complexity
b. Difficulties in managing complex projects	b. How project management currently deals with taking in flexibility
c. Identified solutions	c. Opportunities for flexibility
d. Flexibility enablers	d. Implementing flexibility

2.2.2 Case study

To conduct this research, case studies have been executed. The general approach of this case study is to consult four cases in a 2x2 setting, see Figure 7. Variety represented in project management is reflected in finding two more traditional oriented approaches and two more flexible oriented approaches. Each case study consists of an analysis of project documents and two interviews, one interview conducted with a project manager and one with someone closely involved with the project. First, a long list of possible projects has been drawn up together with project managers. With expert judgement, a shortlist of four projects is composed. The management approach is assessed before the interviews based on the framework developed by Strikwerda (2019) to get more insight into the management approach.

Figure 7 The 2x2 set up for the case studies

Analysing case documents

To get insight into the complexities and flexibilities of the project, project documents have been analysed. The goal is to gain insight into where and when the difficulties have been experienced to look at possible solutions. Therefore, it is essential to obtain consistent data. Every project has been analysed on the relevant

documents in advance of the interview and after. This means that part of the approach for analysing the case documents has been developed while analysing all project documents.

Semi-structured interviews

The experiences of project managers are explored to obtain insight into the possibilities and limitations of management of project complexity. According to Longhurst (2003), semi-structured interviews unfold in a conversational manner offering participants the chance to explore issues they feel are essential while the interviewer gets the opportunity to ask a list of predetermined questions. This approach fits the qualitative nature of the research and allows for known unknowns to come up. Open-ended questions form the basis of the interview, followed by sub-questions or "probes" to elicit unstructured responses and generate discussion (McIntosh & Morse, 2015). Eight interviews were conducted within the four case studies. One interview was done with the project manager per case study, and one interview was done with someone closely related to the project. The second interview per case has been done to have two different views on the project and filter the project manager's perceptions if needed. The transcripts of the interviews are available on request.

The interview consists of three parts. Prior to the interviews, two forms were shared to fill in by the interviewees, explained in more detail in chapter 4. In the first part of the interview, some personal information is asked. In the second part, the specific experience of the project manager concerning difficulties in complex project management has been explored. This experience helps to discover where using flexibility could be in place. The third part is about the flexibility enablers (number 3 in Figure 8) and how the project manager would perceive those in his specific situations and in general. This insight will help with finding suitable flexibility options for difficulties in managing complex projects. The software Atlas.ti is used for transcribing the interviews to categorise and quantify topics and arguments.

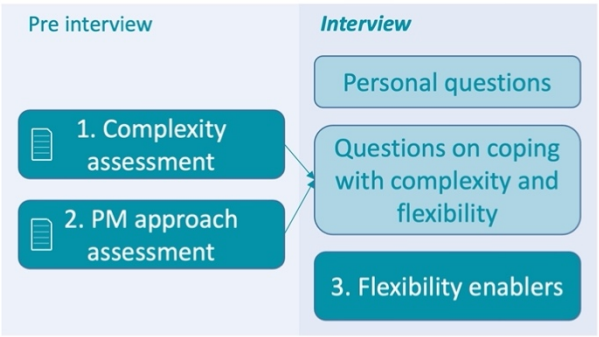


Figure 8 Interview structure and use of forms

2.2.3 Expert consultation

Expert consultation is held to evaluate the recommendations drawn up based on the case study results. The consulted experts are project managers with experience from Arcadis but unrelated to the addressed cases. The session will be held with 3-6 experts.

The consultation was held online via teams and is divided into three parts. In the first part, a presentation about the research and the developed tool was given. The second part is about the recommendations. The experts can vote on the format and usability of the recommendations. Subsequently, the recommendations were discussed with the group of experts. The third part is for questions and tips.

3 Literature overview

This literature overview is meant to establish background knowledge for this research. First, complex projects have been examined and explained to establish a basis for judging complexities in this research. Second, the difficulties of managing complex projects are addressed. After that, the identified ways to deal with complexity are discussed, and finally, flexibility enablers are explored.

3.1 What is a complex infrastructure project?

Construction projects and especially infrastructure projects, are becoming increasingly complex and seem harder to manage (De Rezende et al., 2018; Maylor & Turner, 2017; Wood & Gidado, 2008). First, to understand what complex infrastructure projects are, a general explanation of large infrastructure projects and their characteristics will be presented. Last, related to the construction sector and infrastructure projects, there is still some unclarity of what project complexity precisely is (Luo et al., 2017). Therefore, the definition of project complexity will be clarified through a comparison study.

3.1.1 Large infrastructure projects

Infrastructure projects include roads, rail lines, channels, airports, harbours, bridges, energy network, sewage system, and tunnels (van Wee, 2007). Flyvbjerg (2007) describes the following problematic characteristics of large infrastructure projects:

- Large infrastructure projects are inherently risky because of long planning horizons and complex interfaces.
- Technology is often not standard.
- Decision-making and planning are often multi-actor processes with conflicting interests.
- Often the project scope or ambition level will change significantly over time.
- Statistical evidence shows that unplanned events are often unaccounted for, leaving budget contingencies sorely inadequate.
- Consequently, misinformation about costs, benefits, and risks is the norm.
- The results are cost overruns or benefit shortfalls for most projects.

In addition, projects are bound by the triple constraint of project management which are time, cost and scope and nowadays often quality is added (Jalali Sohi, 2018; Olsson, 2008; Van Wyngaard et al., 2012). The variables are relevant for this research because the industry struggles to deliver infrastructure projects that meet their target budget and planning (Flyvbjerg, 2007). In addition, the management method is relevant since this paper is about managing complex infrastructure projects, and there is not sufficient knowledge of how to manage infrastructure projects that are complex (Eriksson et al., 2017). Large infrastructure projects are often complex due to their many different characteristics (J. Koppenjan et al., 2011).

3.1.2 Defining project complexity

Nowadays, projects become more and more complex. According to Bakhshi et al. (2016), this is due to unexpected emergent behaviour and characteristics. Examples of unexpected emergent behaviour are goal changes, the newness of the technology, scope uncertainties/changes, variety of interests etc. (Bakhshi et al., 2016). To understand the needs for management of a complex project, it is relevant to understand what project complexity is. The definition of a complex project is varied through different studies. Often explanations have an overlap, but details or exact meaning differ. A generic definition is of Hatch (2018), who says complex projects consist of many different elements with multiple interactions and feedback loops between elements. An often-cited definition related to the construction sector is of Turner & Cochrane (1993). They define complexity as the degree of whether the goals and methods of achieving them are well defined. However, this can be seen as a definition that does not cover the load of complexity since complexity involves uncertainty and unknown unknowns, which cannot be defined in advance. Another example related to the construction industry is of Baccarini (1996) and Dubois & Gadde (2002), who mention uncertainties, interrelated parts and interdependencies as characteristics of a complex project. While this definition is more tangible than the definition of Turner & Cochrane, it has more overlap with the general definition of Hatch. In addition, Bakhshi et al. (2016) emphasises unique local conditions, autonomy, emergent behaviours and unfixed boundaries as to be included in the definition of complex projects

These definitions complement each other, and together they seem to fully grasp the definition of project complexity related to the construction sector. To clarify, Bakhshi et al. (2015) state that factors caused by

unfamiliarity and the lack of knowledge are not associated with project complexity, as these factors can be dealt with externally. To conclude, combining the above aspects can lead to a definition of project complexity that includes:

- Manifoldness
- Uncertainty
- Interrelated parts
- Interdependencies
- Non-linearity

Next to definitions that try to explain the meaning of complexity, Maylor & Turner (2017) state complexity as a subjective notion, reflecting the lived experience of the people involved. The Project Management Institute (2013) and Cicmil et al. (2009) state that ultimately, how organisations anticipate, comprehend and navigate complexity determines their successes and failures. This suggests that project complexity in itself is not entirely definable. It is an object of management since understanding a project's complexity is key for adequately resourcing it, and finding ways to reduce complexity should improve project performance (Lessard et al., 2014).

3.2 What are the challenges of managing complex infrastructure construction projects?

Project management is defined as a temporary endeavour to create a unique product, service or result (PMI, 2018). For managing a project, it seems impossible to do everything 'right' (San Cristóbal et al., 2018). As discussed before, this is because it becomes harder to cope with the emerging complexities of projects nowadays. Not everything can be foreseen, and it is still hard to react properly to unforeseen circumstances (Van den Berg & Riemersma, 2021). Therefore, it is relevant to map what difficulties come with managing complex construction projects. First, the difficulties of application of control vs flexibility in management are explored. Subsequent, the impact of the context of a project is presented.

3.2.1 Application of control vs flexibility

In managing projects, there are in basis two extreme approaches, the total control- and the flexible approach (De Rezende et al., 2018). For complex infrastructure projects, it is clear that the traditional (control) approach does not satisfy anymore (Bosch-Rekveldt et al., 2018). In complex project management, there are two main difficulties. The first main difficulty is controlling complex project management; it seems impossible to control a project entirely, while control is often what is strived for at the start and also during the project (Helbing, 2013; Luo et al., 2017). Controlling the entire project is not possible anymore due to, for instance, the dynamics and unforeseen aspects of today. Therefore, it seems easy to say that the opposite, a flexible approach, should come into play. The application of flexibility in project management to cope with complexity is the second main difficulty. The importance of flexibility is often addressed, however, in practice, project management in the construction industry seems to be less flexible (Jalali Sohi et al., 2017).

In complex project management, there is the playfield of the tension of what is needed, flexibility or control? Koppenjan et al. (2011) and Maylor & Turner (2017) address the tension between the desired focus on planning and control and the ambition to remain flexible due to the complexity and uncertainty. In addition, De Bruijn (2012) talks about raising complexity to manage processes better. It can be discussed whether such complex projects become more like processes or require more control as projects do.

To dive further into this subject, we can look at the specific complexities. The managerial approach depends on the complexities; Maylor & Turner (2017) made this relation clear with the project's complexity as an independent variable and a managerial approach as the response. How to manage different kinds of complexities is a challenge. Bosch-Rekveldt et al. (2018) state that the complexities related to interfaces are experienced as hard to manage. Similar is the perspective of Lehtiranta (2011), who emphasises the risks of collaborative working and the effect on performance.

3.2.2 Impact of the project context

The environment wherein management takes place comes with its difficulties. Jalali Sohi et al. (2017) state that even in one organisation, the management approaches differ, ranging from flexible to rigid, and the respective project teams work in different working environments. This ties with San Cristóbal et al. (2018), addressing that the environment affects the degree of definition of project goals and objectives wherein managers have to work, influencing the project complexity.

Next to the environment of a project, the manager plays an essential role in managing complexities. First, the capabilities of the manager (and the team) play a role. Complex projects require proper practices to overcome complexities, where knowledge and expertise are essential for understanding them (Bakhshi et al., 2016; Snowden & Boone, 2007). De Rezende et al. (2018) explicates: "different capabilities must be developed at all levels of the project and strategies, such as learning, selectionism, and integration, to cope with project complexity". Second, the perception of the complexity of the project is relevant. Perfectly described by Maylor et al. (2013) is the impact of perception: "Perception influences the judgment of whether something is complex to manage or not and the degree to which a manager believes he or she can influence the situation". Bosch-Rekveldt et al. (2015) add that the project manager's view is considered most important since he/she has the primary responsibility for the project. Complementary, Jalali Sohi (2018) gives more insight into the perspectives of types of organisations, such as client and consultancies.

3.3 What are the identified ways of managing complex construction projects?

Complexity and its challenges are well-discussed topics in literature. After identification and agreement on the complexities within a project, managers must identify what can be done to deal with these complexities (Maylor et al., 2013). Several researchers have come up with some sort of solution to this problem. This part intends to understand the suggested solutions in the literature by looking at coping with complexity in general and, more specific: identifying and grasping complexity, tools, context-specific solutions and team composition and competencies.

3.3.1 Coping with complexity

According to Snowden & Boone (2007), complex contexts are emergent practices that ask for probe, sense and response. It is identified that it is appropriate to adopt an approach to the complexity that encourages considerations of how order, structure, pattern, and novelty arise from extremely complicated, apparently chaotic systems and conversely, how complex behaviour and structure emerges from simple underlying rules (Cicmil et al., 2009). The balance should be found between guidance and keeping the options open in process management (De Bruijn et al., 2010). From process management can be learned that keeping the options open enables flexibility wherein solutions can be found when the situation requires it. This seems to be in line with the view of Chester & Allenby and Sherehiy et al. (2019; 2007) of organisations that can successfully operate in unstable, changing, and unpredictable environments have the following characteristics:

- organic design characterized by less precise division of labour
- a wider span of control
- a more decentralized authority
- fewer rules and procedures
- more personal means of coordination

3.3.2 Identifying types of complexity in construction projects

Complexity can be divided into several categories to be able to assess the complexity more easily. This categorising has been done in multiple ways in different studies. Girmscheid & Brockmann (2008) divide complexity into Task complexity, Social complexity and Cultural complexity. While the complexities are categorised and clarified a little, it is still hard to work with this division. Maylor et al. (2013) describe three different areas of complexity: Structural complexity, Socio-political complexity and Emergent complexity. In addition, they developed a Complexity Assessment Tool (CAT) to identify the elements of complexity in a project, see Appendix A. The CAT consists of 32 statements that need to be assessed on applicability and judged on the probability of changing.

Somewhat similar but more comprehensive and straightforward is the categorisation of Bosch-Rekveldt et al. (2011). They developed the TOE framework, representing the characteristics of Technical-, Organisational- and External- complexities (see Figure 9). The framework has 47 elements that can be evaluated based on the degree of contribution to the complexity. The **bold** elements in the TOE framework of Figure 9 are suggested to have a stronger link with project performance for projects in general (not specific for the construction sector). Kiridena & Sense (2016) have some overlap with the TOE framework in categorisation but took it to another level in a 'dimensions of complexity'-figure (see Appendix B). They included aspects as dynamic, interactional and structural and distinguished the level of complexness. This

might be too specific for this research. However, the TOE framework can be used to learn how to cope with particular circumstances and evaluate whether a project is complex or just complicated.

Bosch-Rekveldt et al. (2018) elucidate in their research that for the construction sector, there are specific elements of the TOE framework that contribute most to the complexity, these are the following:

- **T-elements:** Uncertainties in scope, Project duration, Dependencies between tasks and Involvement of different technical disciplines.
- **O-elements:** High project schedule drive, Lack of resource and skills availability and Interfaces between different disciplines.
- **E-elements:** Remoteness of location, Interference with existing site/projects, Political influence, Variety of external stakeholders' perspectives and Number of external stakeholders.

T	O	E
Technical Complexity (17 elements)	**Organizational Complexity** (17 elements)	**External complexity** (13 elements)
High number of project goals	**High project schedule drive**	Level of competition
Non–alignment of project goals	**Lack of Resource & Skills availability**	Instability of project environment
Unclarity of project goals	Lack of Experience with parties involved	Company internal strategic pressure
Uncertainties in scope	Lack of HSSE awareness	**Lack of experience in the country**
Strict quality requirements	Interfaces between different disciplines	Remoteness of location
Project duration	Number of financial sources	**Interference with existing site**
Size in CAPEX	Number of contracts	Required local content
Number of locations	Type of contract	**Lack of company internal support**
Newness of technology (world–wide)	Number of different nationalities	Political influence
Lack of experience with technology	Number of different languages	Dependencies on external stakeholders
High number of tasks	Presence of JV partner	**Variety of external stakeholders' perspectives**
High variety of tasks	Involvement of different time zones	Number of external stakeholders
Dependencies between tasks	Size of project team	External risks
Uncertainty in methods	Incompatibility different pm methods / tools	
Involvement different technical disciplines	**Lack of trust in project team**	
Conflicting norms and standards	Lack of trust in contractor	
Technical risks	Organizational risks	

Figure 9 TOE-Framework (Bosch-Rekveldt et al., 2011)

3.3.3 Grasping complexity

As discussed in the previous paragraph, a framework is required to grasp project complexity. Bosch-Rekveldt et al. (2011) propose using the TOE framework to adapt the front-end development phase to the particular project complexity to manage the project better. Maylor et al. (2013) state something similar but more stepwise based on their framework Complexity Assessment Tool (CAT): "Our work has three main implications for organizations. The first, following from the assessment of complexities via the CAT, is that complexity can be actively managed; the project team can remove, reduce, or proactively address sources of complexity. The second is that projects can be selected based on their complexity. Third, project personnel and processes must be fitted to the particular residual complexities a project faces.". While this approach seems very comprehensive, the CAT framework itself is less clear than the TOE framework, as it is less comprehensive, and the statements are hard to judge with just a yes or no answer. However, the Active complexity management approach is insightful, as they describe an approach around the theory for assessing the complexity. Active complexity management consists three steps; a profile, a response, and the implications for the project. First, the profile of complexity should be formed, then with the complexities mapped in a profile, a response can be formed. The response is about matching the complexities to the proper project implementation in terms of preconditions. Last, the project implications should be clarified, also during the project. For many methods for grasping complexity, the 'Active complexity management' method is implied.

3.3.4 Tools

With grasping the complexity, sense can be made of the range of potential responses (Maylor & Turner, 2017). With this additional insight, the different kind of complexities can be adequately addressed. Standard project management tools like PMI BoKGuide and PRINCE2 have application in responding to structural complexities, they are less useful in responding to socio-political complexities and may even conflict with certain responses to emergent complexities (Maylor & Turner, 2017). For complexities where there are no standard approaches, it can still be hard to respond properly. Several examples of flexibility as an approach to prepare for the effects of uncertainties in planning are found by Sager (1990). He also points out that in practice, it is often spoken of but rarely scrutinized theoretically.

3.3.5 Context-specific solutions

Also, more specific solutions are proposed. An example is of Chang et al. (2013), who identified that the Integrated Master Schedule (IMS) could be used to communicate and negotiate project realities and aid in creating a shared understanding of the work among stakeholders as a response to those complexities. Another example is the Soft System Methodology (SSM) to face the challenge of socio-political complexities (Frank et al., 2011; Maylor & Turner, 2017; Staadt, 2012a). In general, it can be said that specific approaches work primarily for complexity that can be handled with structure/control, most often seen as the technical complexity but here examples can be found for other complexities.

3.3.6 Team composition and competencies

Another field of finding solutions for handling complexity is with the people themselves. Competencies and team composition play a role in handling complexities and can help overcome them. It is suggested to look at the development of project managers' competencies and couple those competencies to complexities that require those (Bosch-Rekveldt et al., 2011; Remington & Pollack, 2007; Thomas & Mengel, 2008). Maylor & Turner (2017) suggested something similar, they stated that it helps matching people with the task and planning. As an example of relevance, The College of Complex Project Managers (Australia) even developed a "Competency Standard for Complex Project Managers" (DMO, 2006).

3.4 What are flexibility enablers?

To understand flexibility enablers in general, they are explained first. Second, the need for flexibility for coping with complexity is demonstrated. Third, some flexible management methods will be presented to give a picture of flexibility in management. Fourth, several studies are highlighted to understand where we currently are in the study on using flexibility to manage complexity. Subsequently, a selection of flexibility enablers is explained. This part concludes with a framework for applying flexibility in practice.

3.4.1 Flexibility enablers in general

Bucki & Pesqueux (2000) explain flexibility as the ability to adapt to an existing situation in a reversible manner. It reflects the ability to stay operational in a changing environment. An enabler makes something possible. Together they refer to flexibility options that make things possible in this research in the context of managing complexity and, if appropriately applied, make the project management flexible (Jalali Sohi et al., 2019). A quote of Megginson (1963) illustrates the value of being flexible as it is not the most intellectual of the species that survives; it is not the strongest that survives, but the species that survives is the one that is able best to adapt and adjust to the changing environment in which it finds itself.

3.4.2 Need for flexibility for handling complexity

Many organisations accept the need for flexibility in practice, however, the means to achieve flexibility remains elusive (Lansley, 1983; Lim et al., 2007). A different perspective on flexibility related to practice is of Olsson (2004), who describes it as making an irreversible decision more reversible or postponing irreversible decisions until more information is available. As part of flexibility in project management, Eikenland (2001) and Olsson (2004) talk about room for manoeuvring when making a decision if it does not violate the consequences of previous decisions.

A general approach to handling complexity is responding to the unexpected by acquiring knowledge and making it operational by transferring it to activities (Bucki & Pesqueux, 2000). Flexibility is based on the synergy of a generation of flexibility options and a proactive approach, including learning and improvement, scenario management, environmental monitoring and ongoing processes (Paslawski, 2017). The emphasis for handling complexity should be placed on the organisation since the ability to be flexible involves the interdependency of various enablers of an organization, according to Lim et al. (2007). In the organisation, perspectives regarding flexible management are trust, scope flexibility (by contractual flexibility) and proactive management. To achieve each perspective, it is suggested to practice the enablers coupled to Jalali Sohi et al. (2019). A distinction between internal- and external flexibility in projects is proposed by Olsson (2008); he describes it as the difference of how and what requirements will be met. Another approach is the 'crisis management approach' of Walker & Loosemore (2003), when viewed as a learning opportunity, provides a helpful model for coping with the unknown and unexpected that are the known properties of complexity.

3.4.3 Flexible management methods

While it seems complicated to entirely change to and grasp a new management method in practice, it remains a popular topic in literature. For example, lean thinking has been applied in the construction sector through lean construction (Hansen & Olsson, 2011; Koskela, 1992, 2000; Tommelein, 1998). "In a project management perspective, lean thinking means streamlining the overall process to handle changes and open up for right decisions at the right level and at the right time, with as few consequences or interferences to existing or future decisions as possible" (Hansen & Olsson, 2011). Agile as a management method is often tried to apply and has the advantage that it is agile, of course. Agile might seem attractive for the construction sector. However, the construction sector often has settled management methods and radical change of a management style is not desired. There can be learned from methods that are more flexible by taking parts and use them as enablers.

3.4.4 Different studies on flexibility options

More specific flexibility options are also distinguished in literature, in Table 3. These options partly align with the view of Chester & Allenby and Sherehiy et al. (2019; 2007) from paragraph 3.3 (a wider span of control, a more decentralized authority, fewer rules and procedures and more personal means of coordination). A selection from the literature is listed, and examples will be discussed in this paragraph. The selection in this paragraph gives an idea of the possibilities and needs for flexibility required to understand this research. For example, there are flexibility options based on the internal- and external flexibility by Olsson (2008). The external flexibility ('what requirements…') build upon a growing interest in the project owner perspective and highlighting the continuous alignment of projects with strategy. An internal flexibility perspective ('how requirements…') draws on the emerging approaches for project efficiency. Olsson (2008) states that internal flexibility is more crucial than external flexibility due to limited possibilities for improvements for external flexibility related to the effects (costs), see Figure 10.

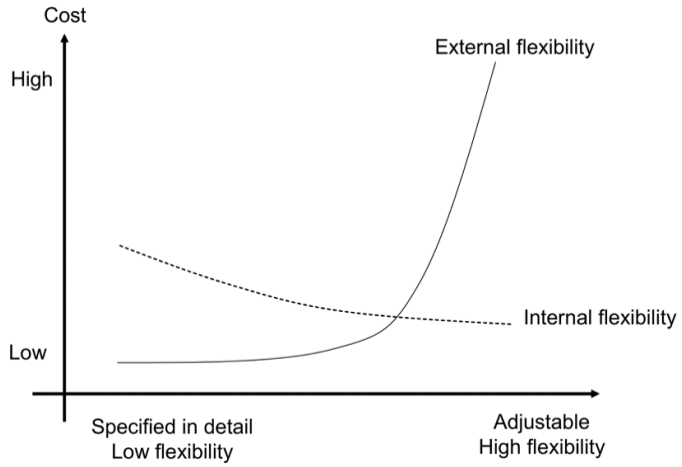


Figure 10 Indication of costs concerning the degree of flexibility for internal & external flexibility (Olsson, 2008)

Another approach is named by Miller & Lessard (2001), who refer to the option of late locking as an exploring, iterative front-end process. Next, Ford et al. (2002), Brennan & Trigeorgis (2000) and Olsson (2004) talk about strategic flexibility as a solution to deal with complexity, more specific they talk about a real options paradigm. Earlier explained by Amram & Kulatilaka (1999) as flexibility compared to owning an option, you have the right, but not the obligation to take any action in the future. Jalali Sohi et al. (2018) identified 26 specific flexibility enablers, eleven of those enablers are specifically for the project process side. Interesting examples of those enablers are 'Self-steering of the complete project team', 'Open and demand-driven information exchange', 'Shared interface management', 'Trust' and 'Network structure rather than a hierarchical structure'. Many of those enablers are already touched upon as relevant in previous chapters.

From this can be learned that there is a relation between including flexibility and the timing and place in the process to do so. To apply flexibility properly, the understanding of complexity and flexibility should be present. Also, flexibility should be used consciously. Studies agree that when flexibility is appropriately used, it will positively influence project success.

Table 3 Flexibility options listed

Author	Method	Goal	Use
Olsson (2008)	Enablers based on internal- and external flexibility	Find the best proportions of internal- and external- flexibility	Find the optimal combination of the two flexibilities to achieve project success
Miller & Lessard (2001)	Late locking	Making commitments not too early to keep flexibility in the project	To make decisions when the time seems right, not to commit too early
Ford et al. (2002)	Real option approach	To value strategic flexibility in uncertain construction projects	Proactively using strategic flexibility by using real options
Brennan & Trigeorgis (2000)	Real Option Theory	To capture latent value in different domains	Application of a real options approach to construction projects
Olsson (2004)	Real option paradigm	To increase the project owner's value of a project	Create the right, but not the obligation to take any action in the future
Amram & Kulatilaka (1999)	Real options approach	To identify valuable opportunities and to adapt to marketplace changes	Valuing growth opportunities
Jalali Sohi et al. (2018)	Flexibility enablers	Coping with complexity by using flexibility in managing projects to increase project performance	Application of the flexibility enablers in managing project complexity

3.4.5 List of Flexibility enablers

Flexibility options for an existing management method are more addressed nowadays. This flexibility option includes all the aspects of Chester & Allenby and Sherehiy et al. (2019; 2007) to successfully operate in unstable, changing, and unpredictable environments. The flexibility enablers of Jalali Sohi (2018) are presented in Table 4. The flexibility enablers are meant to apply to any management method. The 26 flexibility enablers are divided into five categories, what, how, who, when and where. In the research of Jalali Sohi (2018), the 'how' category is proven to have the most significant mediation role of flexible project management for coping with complexities. This overview of flexibility enablers might be used to identify them in the context of a complex infrastructural project or to apply them when complexity has been recognized.

Table 4 Flexibility enablers (Jalali Sohi, 2018)

Category		Flexibility enablers
What	1	Broad task definition
	2	Embrace change as much as needed
	3	Functional-realisation based contract
How	4	Self-steering of the complete project team
	5	Open information exchange among different groups
	6	Shared interface management
	7	Contingency planning
	8	Seizing opportunities and coping with threats
	9	Trust among involved parties
	10	Standardise the process and design
	11	Visualised project planning and progress
	12	Possible alternatives
	13	Network structure rather than hierarchical structure
	14	Continuous learning
Who	15	Consensus amongst team members
	16	Stable teams
	17	Self-assigned individuals to tasks
	18	Team priority over individual priority
	19	Team members as stakeholders
When	20	Late locking
	21	Short feedback loops
	22	Continuous locking (iterative)
	23	Iterative planning
	24	Iterative delivery
Where	25	Joint project office
	26	Have flexible tables

In Table 4, the 'how' category is presented in blue. These eleven flexibility enablers are proven to have a role in coping with project complexity. This aligns with the study of Olsson (2008), who calls this category of flexibility enablers 'Internal flexibility' and expresses the relevance of focus on this flexibility. Therefore, these elements are chosen for further research and applicability. Next, the eleven elements of the 'how' category are explained. The explanation consists of a description (based on Jalali Sohi (2018)) and examples.

Self-steering of the complete project team

This flexibility enabler is about the structure of a project team. As opposed to a hierarchical project team, a self-steering project team is relevant for flexibility in the project. This means that the organisation's steering (project team) has a more horizontal character that encourages role interchangeability (Koppenjan et al., 2011; Nerur et al., 2005). While completely self-steering teams allow the maximum flexibility in that area Jalali Sohi (2018) concludes that teams should be structured for facilitating the decision-making process. Therefore, the structure of the project team might resemble some level of hierarchy. This element is closely related to agile, from where can be learned how to apply this element.

An example from literature is a leadership-and-collaboration management form, where autonomy and cooperation blends to provide flexibility and responsiveness (Nerur et al., 2005). This could entail that the role of a project manager becomes more of a facilitating role, directing and coordinating the team's collaborative efforts (Highsmith, 2003).

Open information exchange among different groups

Open information exchange entails transparency in communication, sharing of information and short communication lines (Jalali Sohi, 2018). Open information exchange must be among all parties involved (J. Koppenjan et al., 2011). Information exchanges due to demand/request (Jalali Sohi, 2018). This can be structured in a system for information where all the parties have access.

Shared interface management

All parties involved should contribute to the shared task of interface management. As the name implies, this involved the management of the interfaces. The shared interface management integrates the organisation and the involved parties in the project, which helps to cope with complexity (Jalali Sohi, 2018). An interface point is defined by Construction Industry Institute (2014) as "a soft and/or hard contact point between two interdependent interface stakeholders in a construction project."

For interface management, several tools can be used. However, research shows that these tools might not be comprehensive enough for dealing with today's project complexity (Ahn et al., 2017). Some explicit examples of interface management are formal procedures for interfacing between parties (interface agreement forms), designating interface managers, establishing data centres for sharing up-to-date project information and documents, and using information systems (Ahn et al., 2017). These examples do not require to be shared based on the method, for functioning as a flexibility enabler, they must be shared.

Contingency planning

Next to the defined base plans, an alternative plan is required. Contingency plans reflect anticipated potential departures from the defined plans for a project (Jalali Sohi, 2018). When the base planning cannot be executed, the alternative(s) can be used.

Seizing opportunities and coping with threats

Here the ability of the decision-making process to deal with unexpected influences without risking indefinite delays or stalemates in the process by identifying opportunities and threats is meant (Jalali Sohi, 2018).

Mapping opportunities and threats at the start of- and during the project and thinking of coping with unexpected happenings.

Trust among involved parties

To establish trust in decision-making, all parties should be involved, information (also incomplete) should be shared, and information should be visible to all parties.

To achieve trust, the method is similar to the method of open information exchange, a system is needed where all parties have access to the specific information required to establish trust.

Standardise the process and design

Standardisation should be used to the extent that it fits with the context of the project to achieve reflective learning (Jalali Sohi, 2018). Standardisation prevents from reinventing the wheel and allows for project-specific additions.

This can be a standard (simple) process, design, layout, etc., usable for similar cases.

Visualised project planning and progress

Project planning and progress should be visible for all parties. Therefore, they must be clear and visible. Facilitating a common space with visualised planning and progress allows for discussions over the project (Jalali Sohi, 2018).

In a shared space, boards, figures, charts, diagrams, etc., can be hanged on a wall. Sharing this information virtually, boards can be made in an online environment.

Possible alternatives

When something unexpected happens, and the ongoing plan cannot be continued, it helps prevent delays to have a possible alternative ready. This is to be flexible when unknown unknowns occur.

Network structure rather than a hierarchical structure

Establishing a network structure as a project organisation structure for decision-making is better. Traditional is seen as destructive (Jalali Sohi, 2018).

Continuous learning

Continuous learning remains a challenge in (complex) projects (Carrillo et al., 2013). Lessons learned should be captured and used in future projects concerning their context (Jalali Sohi, 2018).

Lessons learned should be captured so that the organisation can learn from this in the following similar projects. Many examples could be given. However, the real challenge is the application during projects (Williams, 2008).

3.4.6 Framework to apply flexible project management

Jalali Sohi (2018) composed a framework for applying the flexible project management approach (see Figure 11). To manage projects more flexible, four steps need to be performed iteratively. The first is 'insight', the goal of this step is to obtain insight into the project complexity and applied project management approaches. The second step is 'importance'. The goal of this step is to create awareness of the practioners' mindsets. The third is 'implementation'. The goal of this step is to implement the flexibility enablers in practice. The fourth is 'Improvement'. The goal of this step is to look for improvements. The iterative character of this framework helps for continuous improvements in the practice of flexible project management.

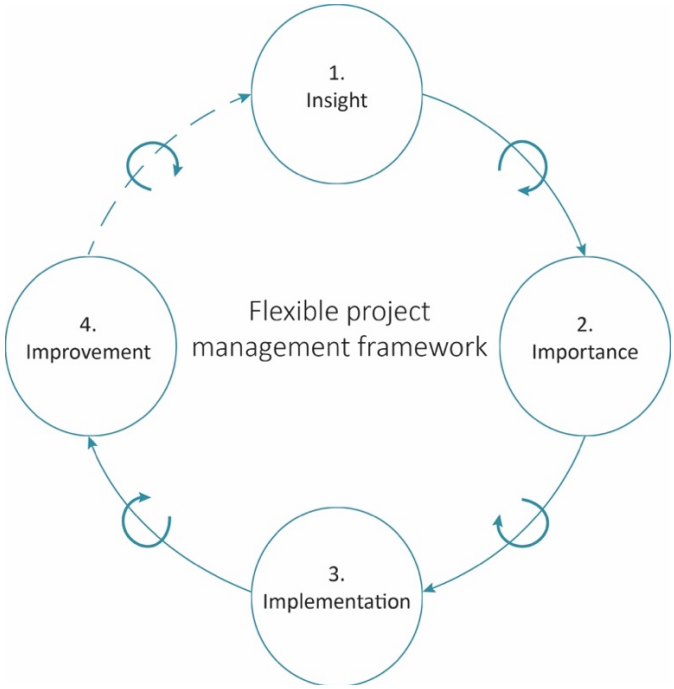


Figure 11 Flexible project management framework (Jalali Sohi, 2018)

3.5 Conclusion

The literature study helped to obtain insight into the managerial practices in relation to project complexity. This chapter answers the second sub-question of this research:

| SQ 1: What are the challenges in the management of complex projects?

Managing complex projects is perceived as challenging. The current management methods do not always satisfy to manage complex projects. Ford et al. (2002) stated that the complexities could not be resolved adequately through improved control. Project Management Institute (2013) adds that complexity will not disappear and will only keep increasing.

In recent years complexity in engineering is investigated more thoroughly and has made advances by analytically decomposing the core concept of complexity into more specific theories. While intuition for the significance of complexity is gained by researchers and managers, coping with complexity in practice still seems to remain challenging (Lessard et al., 2014). Grasping complexity can be done utilizing a framework to help understand the complexity, for instance, the TOE framework composed by Bosch-Rekveldt et al. (2011). The TOE framework has been used in this research to assess complexity. More specific, the elements that contribute most to the project complexity in the construction sector has been taken in (Bosch-Rekveldt et al., 2018):

- T-elements: Uncertainties in scope, Project duration, Dependencies between tasks and Involvement of different technical disciplines.
- O-elements: High project schedule drive, Lack of resource and skills availability and Interfaces between different disciplines.
- E-elements: Remoteness of location, Interference with existing site/projects, Political influence, Variety of external stakeholders' perspectives and Number of external stakeholders.

Adopting a new management method to deal with the complexities does not come naturally and does not seem the desired solution (Jalali Sohi, 2018). Therefore, the complexities must be mapped with the TOE framework, and management should be adapted accordingly. However, adapting the management accordingly to the complexities of a project is not as easy as it may sound. De Rezende et al. (2018) has stated that due to the shift of focus to project adaptability, it is necessary to explore and develop capabilities to manage complex projects on the organization, team, and project level. In line with this view, Jalali Sohi et al. (2019) advises further development of their research into how to embed the flexibility enablers into practice, considering the different perspectives and commonalities. Eleven flexibility enablers of the category 'how' are selected for this research because they have proven a positive relation for coping with project complexity (Jalali Sohi et al., 2019):

1. Self-steering of the complete project team
2. Open information exchange among different groups
3. Shared interface management
4. Contingency planning
5. Seizing opportunities and coping with threats
6. Trust among involved parties
7. Standardise the process and design
8. Visualised project planning and progress
9. Possible alternatives
10. Network structure rather than hierarchical structure
11. Continuous learning

These enablers have been further examined in the case study to determine how they can be applied in practice. This will require further research on how and when flexibility should be applied and whether this is possible to add to an existing management method. In addition, the process of the Flexible project management framework of Jalali Sohi et al. (2019) has been used throughout this research to conduct structured research related to the implementation of flexibility in management.

It can be concluded that challenges in managing complex infrastructure projects are grasping the complexity and embedding flexibility. With the theoretical background established and frameworks found in literature, a starting point is created to research how flexibility can help facilitate the management of project complexity.

4 Case study

In this chapter, the case study approach and case selection are described.

4.1 Case study approach

Each case study consists of two semi-structured interviews and an analysis of the matching case documents. In Figure 12, the approach is visualized. First, a complexity assessment form (see Appendix D) is administered to map the complexities from the interviewees' perspectives (number 1 in Figure 12). In addition, a management approach form (see Appendix E) is given to the interviewees to validate the management approach (number 2 in Figure 12). After receiving the two forms, a semi-structured interview is conducted to gain information about their experiences related to complexity, how they coped with complexity and selected flexibility enablers (number 3 in Figure 12).

The interview starts with the question: 'What do you think of when it comes to flexibility in managing complex projects?'. This gives the interviewee the chance to define flexibility freely. The answer of the interviewee was written down in a word web which was shared via Teams. The question is meant to get the interviewee talking about his/her view on flexibility. The interview questions consist of three parts: a personal part about the interviewee, a part about complexity in the project and a part about flexibility (see appendix C for the semi-structured interview guide). Twelve main questions have been composed to ask with possible complementing questions. Not all questions need to be asked explicitly by the interviewer; the idea is to start with the first question on a topic and let the interviewee talk. When the interviewee deviates from the subject, the questions will get the interviewee back on track to continue the interview on the relevant topics. These questions should result in the required data on the projects.

The individual analysis and the cross-case analysis are based on the gathered information from the document analysis and the semi-structured interviews. The case studies are anonymised for privacy reasons. In Figure 12, the input and output of all the individual parts (forms, analysis and interview) are shown with the arrows.

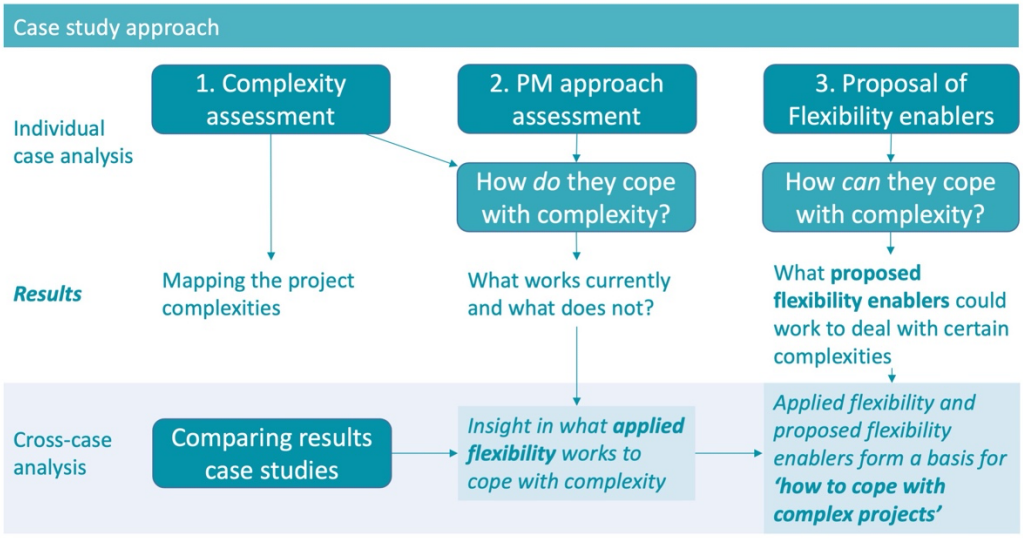


Figure 12 Case study approach for individual and cross-case analysis

1. Complexity assessment

To apply focus in this study, it is chosen to select five complexity elements from each category of the TOE framework. This enables the interviewees to think of the specific complexities and how they are present and handled in the projects. The selection is based on the 12 elements that contribute most to project complexity in the construction sector (Bosch-Rekveldt et al., 2018), as discussed in Chapter 3.3.2. In addition, complexity elements have been gathered by conducting brief interviews with experienced project managers about project complexity. The elements have been added to the selection of literature from the TOE framework and presented in **bold** in Table 5. Together this results in a complexity assessment form with 15 elements that can be judged by the interviewees on a scale from zero to four for the contribution to the project complexity (see Appendix D).

Table 5 Selected TOE-elements

Technical complexity	Organisational complexity	External complexity
1. Non-alignment of project goals 2. Uncertainties in scope 3. Project duration 4. Dependencies between tasks 5. Involvement different technical disciplines	6. High project schedule drive 7. Lack of resource & skills availability 8. Interfaces between different elements **9. Size of project team** **10. Lack of trust in project team**	11. Remoteness of location 12. Interference with existing site 13. Political influence 14. Variety of external stakeholders' perspectives 15. Number of external stakeholders

2. Project management (PM) approach assessment

The projects have been selected based on the project management approach, whether it is a more controlling or flexible approach. To know more about the management approach, it is desirable to ask more precise questions to find out what the approach of the project managers is. Therefore, a form is made based on the thesis of Strikwerda (2019) and the research of Koppenjan et al. (2011) (see Appendix E). The theoretical framework to determine the project management approach is analysed and adjusted to fit this research. With the framework, the predominant approach per category (traditional vs flexible) can be identified and mapped by the interviewees based on a scale with an explanation. The categories are terms of reference, task definition, contract, incentives, change, steer, information exchange and interface management. This information on the project management approach helps find the flexibility applied in the project and has been used to process the data on complexity and flexibility.

3. Flexibility enablers

At the start of the interview, the view of the interviewees on what flexibility in the management of complex projects means to them is asked. Next, the use of flexibility has been analysed during the interview to see what the interviewee comes up with. Lastly, the selected flexibility enablers will be shown as a list, and the interviewees are asked to give their view on applying these flexibility enablers in the project (see Table 6).

Table 6 List of flexibility enablers shown in the interview based on Jalali Sohi (2018)

Category		Flexibility enablers	NL vertaling
How	1	Self-steering of the complete project team	Zelfsturing van het complete projectteam (in het netwerk)
	2	Open information exchange among different groups	Open informatie-uitwisseling tussen verschillende groepen. (Vraag gestuurd)
	3	Shared interface management	Gedeelde interface management
	4	Contingency planning	Noodplanning
	5	Seizing opportunities and coping with threats	Kansen grijpen en omgaan met bedreigingen (in besluitproces)
	6	Trust among involved parties	Vertrouwen onder de betrokken partijen
	7	Standardise the process and design	Standaardiseer het proces en ontwerp
	8	Visualised project planning and progress	Gevisualiseerde projectplanning en voortgang
	9	Possible alternatives	Mogelijke alternatieven
	10	Network structure rather than hierarchical structure in organisation	Netwerkstructuur in plaats van hiërarchische structuur in organisatie
	11	Continuous learning	Continu leerproces

4.2 Case selection

Four projects have been chosen for the case study. Because the cases are selected for an in-depth case study, the 'diverse' approach of Seawright & Gerring (2008) is selected. In this approach, the essence of the projects is diverse, but having some similarities is possible to broaden the general analysis of the causal relationships. Due to their similarities, the variation in the object of research (or unit of analysis) was visible and could be compared between the cases to create the data needed.

For this research, the four cases all met the following requirements:

- The project is an infrastructure project
- The project is a large-scale project costing more than 20 million euros (Cantarelli et al., 2012)
- The projects have the same management method (TAW)
- Two of the four projects are indicated to have a more flexible approach
- Two of the four projects are indicated to have a more traditional approach
- The assignments are in the front-end phase of the project
- Assignments must be (almost) finished
- Three types of complexities (TOE-framework) should be present in the project: Technical, Organizational & Environmental complexity.
- Project managers are experienced (5+ years)

The requirement for experienced project managers is chosen to rely on their experience for judging the project complexity, project management approach and flexibility related to the project (scored in the forms and for during the interviews).

A long list of suitable projects has been established to select four projects for the case study. Conversations with project managers were held to receive the information on the projects needed for a longlist. From these conversations, it turned out that there were six promising projects. In the longlist, there were multiple rail projects, road projects and projects with the same client. It was chosen to have various projects and clients within the same management approach (of the 2x2 setting). This will allow for a variety of management approaches to come up in the four projects (how complexities are handled). The following projects with corresponding interviewees were selected from the longlist (see Table 7):

Table 7 Overview of the interviewees

	Project	Client	Interviewee	Age	Function	Experience PM (years)	First indication of the management approach
A	Tramline	Province / Engineering firm	A1	46	Project manager and design manager	10	Traditional
			A2	37	(Civil) Design leader	5	
B	Junction	Executive agency of the Ministry	B1	48	Project manager	10	Traditional
			B2	47	Environment manager	20	
C	Highway	Executive agency of the Ministry	C1	59	Project manager	22	Flexible
			C2	44	Manager project control / Contract manager	15	
D	Workshop for trains	Railway company	D1	38	Project manager	15	Flexible
			D2	36	Manager project control	5	

5 Individual cases

All cases have been worked out systematically based on an identical structure. The following reading guide contains non-case specific information and can be used to understand the design of this chapter. A selection of the elements is presented in the descriptions (the others can be found in Appendix G).

5.X.1 General description

First, a general description of the project is presented. This description was based on an analysis of the project documents and interviews. First, the project characteristics have been summarized to give a quick overview of the cases. Subsequently, a project and assignment description is given.

5.X.2 Project complexity

The project complexity, in general is discussed first to recognize and emphasize the complexity of the project. Subsequently, to grasp the project complexity, the project is analysed with the interviewees based on the TOE framework.

5.X.2.1 General

First, the dominant contributor to complexity, according to the interviewees, is described. Next, the characteristics of project complexity, as explained in Chapter 3.1.2, are linked to this project.

5.X.2.2 TOE

In each case, a figure is presented, which visualizes the given scores of the interviewees on the contribution of the elements to the project complexity. Subsequently, the scores of the elements are explained based on the information of the interviewees. The scores are given between brackets, respectively, for interviewee 1 and 2. Note, the explained complexity is the interpretation of both interviewees of the case unless stated otherwise.

5.X.3 Project management approach

In this section of each case, the figure represents the given scores of interviewees on the management approach in the assignment. After, a short explanation is given. In appendix G, each aspect of the project management approach is elucidated based on the project documents and interviews of the project. The given scores are repeated between brackets for each explanation, respectively, for interviewee 1 and 2.

5.X.4 Flexibility

First, flexibility findings from the cases are given. Subsequently, the cases are analysed with the interviewees based on the selected flexibility enablers.

5.X.4.1 Flexibility from the case

In project management, some flexibility became visible during the case analysis, mainly from the interviews in the second part (on project complexity and how they coped with it). In this section, the observed flexibilities are explained: when was flexibility incorporated and what was the effect? The headings of the flexibility from the cases are based on the themes of the findings to oversee the topics in which operationalisations were found quickly.

5.X.4.2 Flexibility enablers

The flexibility enablers are discussed in the final part of the interview. In this section, the views of the interviewees on the selected flexibility enablers are explained. First, the opinion of the interviewees is visualised in a figure and subsequently explained (with scores added between brackets).

5.X.5 Flexibility web

At the beginning of the interview, the interviewees were asked what came to mind when thinking of flexibility in managing complex projects. While answering this question, the interviewer created a web. These webs give an idea of what the interviewees identify as flexibility in complex project management. These views can help the reader understand the attitude towards the flexibility enablers in section 5.X.4 of all the cases. The word webs are presented in English; the original version can be found in Appendix F.

5.X.6 Main findings

As a final part of the cases, the main findings of the case are presented. These are the findings that were explained to have the most impact.

5.1 Case A – 'Tramline'

5.1.1 General description

Project:	Tramline
Client:	Province (initial client), Engineering firm (contractor of initial client)
Goal client:	Conversion of tramline with little nuisance possible
Phase contractor:	Design phase
Budget project:	± € 70 million
Budget assignment:	± € 6,6 million
Project duration:	4 years
Duration assignment:	7 months
Main objective:	Creating an integral, verified and validated design for the client with a safe and maintainable design. This includes the correct level of detail for realization and management.

Project Tramline consists of the conversion of a whole tramline trajectory. The tramline runs through different cities and is commonly used. To keep the nuisance for execution to a minimum, the tramline will be out of service in summer, and therefore a tight schedule is needed.

The trajectory will be adapted to the new trams coming, which are longer and have a lower entrance. More than 20 platforms on the trajectory need to be lowered and extended. Also, around 20 kilometres of track and overhead lines should be renewed. The tramline will be connected to another tramline to establish one ongoing tramline.

In project Tramline, the assignment for Arcadis was to make the design of the conversion for the engineering firm. The assignment needs to be executed in seven months, during which Arcadis draws up the design of the track, the stops, the overhead wires, the structures and all installations. In addition, Arcadis provides the Safety Case and the safety & health measures for the people who work on the construction site and the railway.

To execute this phase of the project, the Final Design and Implementation Design are drawn up. First, the reference design is checked, together with the verification report, and used as a basis. Next, the design approach starts with analysing the contract using the requirements analyses of the Demand Specification and requirements based on other binding and informative documents. The assignment is managed by monitoring and steering the Key performance indicators on the processes planning, finances, satisfaction, quality, and risks.

5.1.2 Project complexity

Project complexity in general

According to the interviewees, the overall project complexity is mainly a result of the uncertainties in scope and the project's duration. There is a high project schedule drive, with many and unclear expectations.
Manifoldness: The project involves many different disciplines and tasks with many interfaces and dependencies.
Uncertainty: There is much uncertainty in expectations from the initial client and scope.
Interrelated parts: The design has many interrelated parts, such as overhead lines with the rails.
Interdependencies: Arcadis is dependent on the initial client for the scope and vice versa. In addition, almost everything in the design is related to each other, which means there are many more interdependencies.
Non-linearity: Due to the dependencies and uncertainties, it is an uncertain and iterative process in which information must be collected. It can be taken along or adjusted in the project.

Complexity assessment based on the TOE-framework

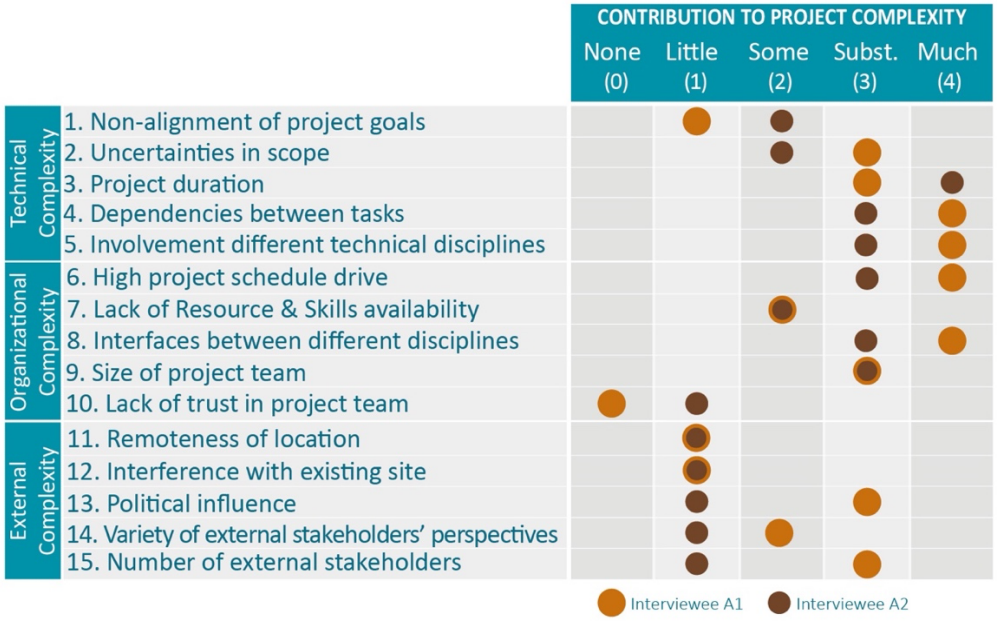


Figure 13 Complexity assessment of two interviewees of project 'Tramline'

The technical- and organisational complexity are highest and external complexity is relatively low.

Technical complexity

Dependencies between tasks (4&3): Interviewee A2 explained that for executing the assignment, Arcadis was dependent on the information given by the initial client (which was insufficient), which made it complex. Also, the different disciplines depended on each other's tasks, which resulted in a snowball effect when something changed. Due to the short duration, there was extra pressure on the dependencies, and there was no margin for error.
Involvement different technical disciplines (4&3): Interviewee A1 states there were 14 technical disciplines. Due to insufficient information, all those disciplines started working in the uncertainty of what their work exactly entailed. In addition, all those disciplines have their specific way of working, which does not result naturally in one integral design. In addition, interviewee A2 mentioned that communicating and making sure that you are on the same page is a significant challenge.

Organisational complexity

High project schedule drive (4&3): The assignment was planned to be executed in little time; this caused the assignment to be under time pressure. Also, due to the uncertainties, the pressure was extra high. No fallback scenario was possible.

> *"We kept thinking about whether we wanted to link our name to this project. If it does not work out, it is us, as Arcadis, that failed to deliver, while it was primarily not our problem that we had to solve."*
>
> Quote of interviewee A2

Interfaces between different disciplines (4&3): Many disciplines were present with interfaces between them. The exact interfaces were not always clear due to the incomplete design of the alignment, which caused the designs of the different disciplines (and interfaces) to be adjusted. Much detail was required because of time pressure and that there was no room for mistakes.

"Design had to be 100% right so that it could be built properly in one go. This meant there was pressure on dependencies that normally require much attention, but now there was no time for that."

Quote of interviewee A1

5.1.3 Project management approach

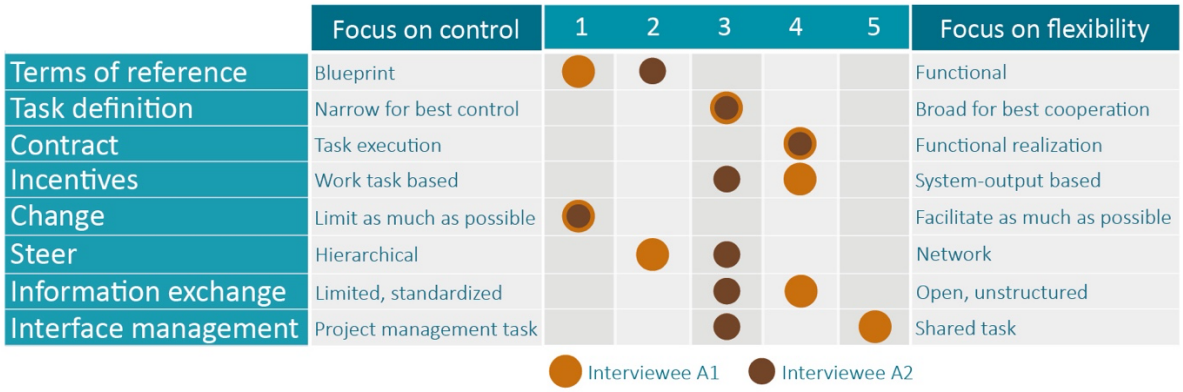


Figure 14 Project management approach assessment of two interviewees of project 'Tramline'

On average, interviewee A1 scored the project management approach focus between control and flexibility with widespread elements (see Figure 14). Interviewee A2 scored slightly more towards the focus on control but generally scored average. This deviates from the estimated project management approach, which was more traditional.

5.1.4 Flexibility

Flexibility in project management from the case

Planning:

- To keep working on schedule despite the high time pressure, **LEAN planning** was composed **on day level**. This required a wall of 15 meters long to hang up the planning and make it visible.

Communication:

- Communication with all the different technical disciplines was a challenge due to their different ways of working and communicating. To make sure you talk about the same thing, it is good to **validate**. It helps to **visualize** to solve a technical issue. When something is drawn, everybody can see it and will probably understand the issue.

Support and motivation for the assignment:

- The time pressure affected the motivation of the team. First, to **create support in the team of Arcadis, it was much discussed and explained how** they were going to finish the assignment together. Next, their strategy is communicated with the Engineering firm, to be honest, and open about the situation.
- To keep working with a motivated project team towards the same goal, the engineering company hired a cooperation coach as part of the MEAT criteria promises. The coach helped when discussions put pressure on the cooperation in the team (mainly between the different parties).
- The time pressure also had its effect on the motivation of the team. To remain credible and keep up the motivation, several things were initiated, such as **LEAN planning, additional sessions for changes, personal responding to people's feelings by means of personal attention, additional collaborations and organizing team games.**

Interfaces:

- Because there was a lot of time pressure, there was not always enough time to align interfaces. It comes down to **experience and gut feeling,** and it is essential to **use experienced people** to see if everything is going well.

- Nobody felt responsible for the specific interfaces. Therefore, **interface sessions** were held, and **tasks were delegated and assigned in a system** for people to start taking care of the interfaces. These actions were reactive to the situation.

Flexibility enablers and project Tramline

Flexibility enablers	A1	A2
Self-steering of the complete project team	±	−
Open information exchange among different groups	+	+
Shared interface management	−	−
Contingency planning	±	+
Seizing opportunities and coping with threats	+	+
Trust among involved parties	+	+
Standardise the process and design	+	±
Visualised project planning and progress	+	+
Possible alternatives	+	+
Network structure rather than hierarchical structure	±	±
Continuous learning	±	±

Figure 15 Attitude towards selected flexibility enablers of the interviewees from project Tramline

Selected flexibility enablers

Self-steering of the complete project team (±☹-): Interviewee A1 does say self-steering is an important aspect, however, to make it work, discipline leaders are necessary between the project manager and the sub-teams. Interviewee A2 thinks that they might not have succeeded in this project when there would be less control and more self-steering in the project:

"Assumption is the mother of all fuckups. It could also be the nature of the bug."

Quote of interviewee A2

Open information exchange among different groups (+☹+): The interviewees see this as an essential aspect. In the assignment, information sharing could have been better because often, only the end product was shared. It would be better to regularly share drafts, which would help to get more insight into interfaces.

Shared interface management (-☹-): Interviewee A1 learned from a previous project that it is crucial to point out someone for the job of interface manager. In this project, the interface manager also had other tasks, and the task of interface management was neglected. Interviewee A2 mentioned that interface management was a shared responsibility in the design team, so nobody felt responsible for interfaces. Both interviewees agree that the interface manager should be pointed out specifically and dedicated to only that task.

"The role of the interface manager should have been active and leading. Someone who had started to work on this in terms of content. To visualize things and problems and make them concrete. Interface manager often becomes only a paper function."

Quote of interviewee A2

Trust among involved parties (+☹+): Both interviewees think of this as an important aspect. Trust was high in the team of the assignment with the Engineering company. According to the interviewees, trust in the initial client was low despite the cooperation coach, mainly because the initial client was not competent for the job.

Visualised project planning and progress (+☹+): The planning and progress were visualised using LEAN planning on a long wall. This resulted in a planning that everyone supports and has contributed to. With a daily stand, the planning and progress were discussed, and everyone got closely involved.

"Because everyone sticks their sticky notes of what they are going to do and how they coordinated it with others, there is a supported planning, and they feel responsible for it themselves. However, LEAN planning is not flexible; stickers are analogue, so it will not be easy if you want to slide. You do not know the implications. You cannot link it, and then you lose the overview."

Quote of interviewee A1

Network structure rather than hierarchical structure (±&±): Both interviewees agree that a network way of working can be created for the optimal working structure based on a hierarchical structure.

"The project manager's style should be network-oriented. PMs should not get involved in everything. Letting the people of the team determining things themselves gives them a feeling of responsibility. Hierarchy is needed for making decisions. With open and specific questions gauge how things are going in the team, the PM can always indicate whether it might not be a good idea. In such a way that the team themselves are made to think."

Quote of interviewee A1

Continuous learning (±&±): Interviewee A1 says there was no time for continuous learning, they were conscious of this fact and accepted it. In the end, there was a comprehensive evaluation. In addition, interviewee A2 mentioned that they did observe what did and did not work in between the phases.

What might be seen as a form of continuous learning is the strategy of forming a team. Interviewee A1 states he knows quite many people in disciplines and knows whom he needs for what tasks. When A1 did not know the people he needed for the key functions, other people's experience and opinion were consulted. In addition, he interviewed them in advance to find out whether they would fit the function. The right people with the right experience were tried to put on the team.

Also, interviewee A1 indicates they were consciously engaged in the team's long-term ambitions by considering people's future perspectives. This was, for instance, done by letting someone inexperienced go with someone more experienced. This was possible for two people, but it could not be done with all the 60 people in the team. The two people also had separate conversations with the cooperation coach and experienced this learning trajectory very positively.

5.1.5 Flexibility word webs

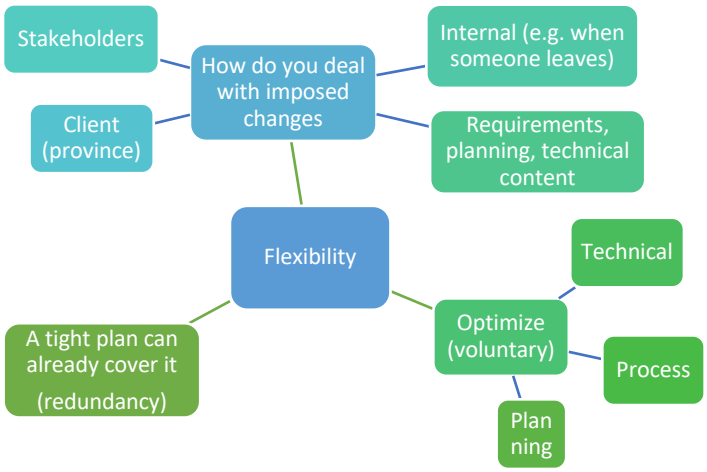


Figure 16 Flexibility web of interviewee A1 - EN

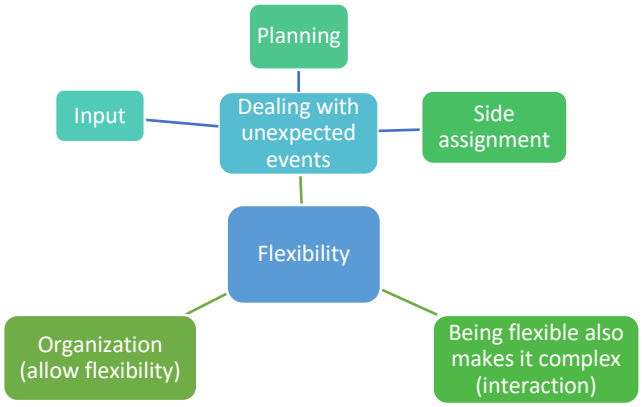


Figure 17 Flexibility web of interviewee A2 - EN

The views on the flexibility of the two interviewees differ. It is observed that interviewee A1 thinks of flexibility as redundant, a reacting strategy for dealing with changes or optimisation. It seems that interviewee A1 does not think of flexibility as a strategy to cope with the complexity elements that contribute much to the project complexity, while in practice, flexibility is applied in project management. Interviewee A2 does see flexibility as a strategy for dealing with complexity. However, the interviewee also thinks it depends on the organisation and sees flexibility contributing to the project complexity.

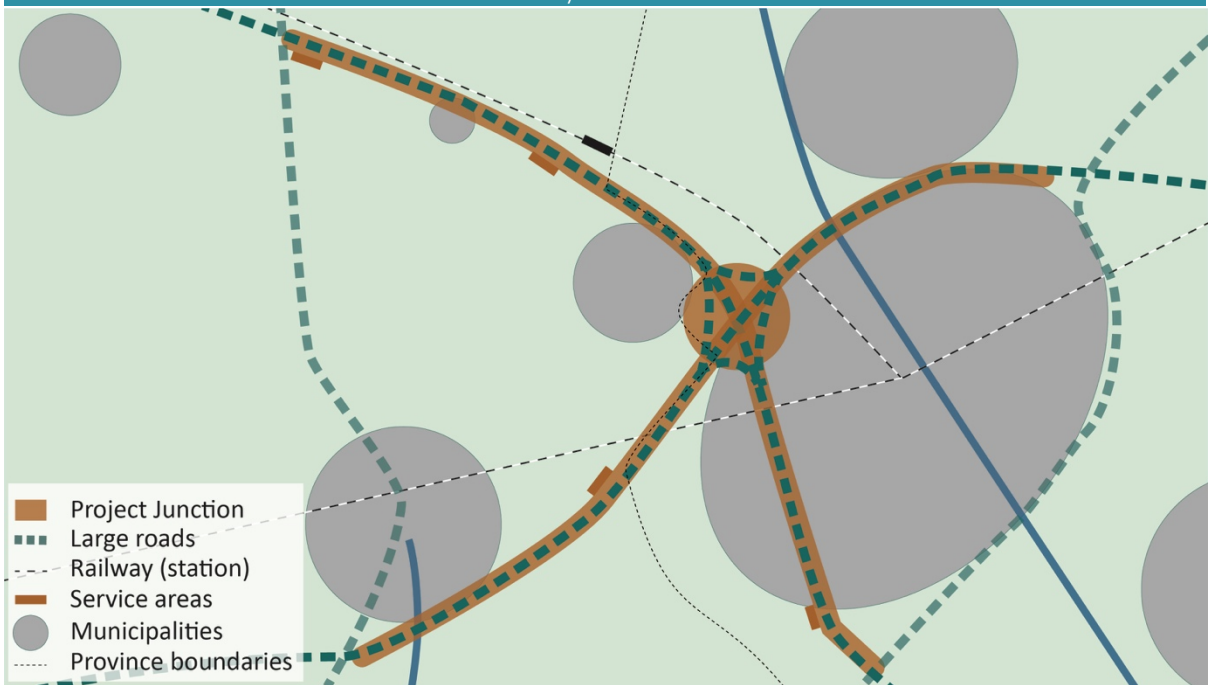
5.1.6 Main findings

- Time is an important aspect of flexibility
  - Having some spare time in the project gives room for creativity.
  - Less time pressure gives room for seizing opportunities and coping with threats and serving the initial client additionally to the scope
- Trust and support for the project are a basis for an effective and initiative-taking team that helps with the project's flexibility.
  - Involve the team in the process and share responsibility
  - Asking open questions and let the team think, involve everyone and earn the trust
- Having clear ways to communicate is important
  - Visualizing is an essential aspect of communicating for understanding and knowing that you are on the same page.
  - Having a basic structure for the process gives a clear basis for information transfers and communication

5.2 Case B – 'Junction'

5.2.1 General description

Project:	Junction of highways
Client:	Executive agency of the Ministry
Goal client:	The basic principle of project junction is that all traffic flows are given more space and with good integration into the landscape, which improves accessibility and quality of life in the region
Phase contractor:	Planning phase
Budget project:	± € 417 million
Budget assignment:	± € 5-8 million
Project duration:	8-10 years
Duration assignment:	7 years
Main objective:	The consortium will execute the integrated project approach through planning, design, and construction, considering the client's wishes as much as possible. Attention will be paid to minimizing the nuisance during the work with maximum attention to sustainability.



Project Junction consists of redesign and widening the junction and the associated roads to give more space for the traffic flows. The project is situated in two provinces, five different municipalities, a water authority, affects various private lands, crosses the railway twice, has many connecting and intersecting roads and is a vital vein for fast motorized traffic.

The project includes many different entrances/exits of the corresponding highways with regional roads around the interchange. In addition to widening the roads, the layout of the roads is adapted to the possible routes to split the traffic and streamline the traffic flow. Other important connections around the motorway are included in the project, such as waterways, cycle paths and walking connections. The area around the project is also taken in, such as highway service areas, a small train station, and surrounding nature.

In project Junction, the assignment is done by a combination. This means Arcadis works with other contractors on the total of the assignment. The combination works from a Plan, Design & Construct contract, which means it entails both the plan elaboration and the realization of the junction.

The contribution of Arcadis to the assignment is broad and diverse and is mainly focused on the planning phase. The Arcadis part entails landscape integration, drawing up a digital Environmental Impact Assessment (EIA), design plan approval decision (OTB) and draft remediation decision (OSB), specialist sub-studies and stakeholder management.

5.2.2 Project complexity

Project complexity in general

According to the interviewees, the overall project complexity is mainly a result of the new contract form and thereby the interest of parties that usually work in different phases, that now had overlap.
Manifoldness: The project is large and involves many different disciplines with many interfaces.
Uncertainty: The new way of working for this project brings much uncertainty on how to proceed and what can be expected from the parties. In addition, the client is not familiar with the new contract form, which gives uncertainties for Arcadis.
Interrelated parts: Next to interrelated parts in the project itself, the project is under high pressure because the road should be improved while the traffic flows cannot decrease while executing the project. These parts are all interrelated.
Interdependencies: In the projects, many tasks and disciplines are interdependent. In addition, many dependencies are new to the parties due to the new working method (contract form).
Non-linearity: Because the project cannot affect the current traffic flows and the contract form, the project cannot be linear. The process is iterative, and everything that should be executed must be carried out gradually and in segments running parallel.

Complexity assessment based on the TOE-framework

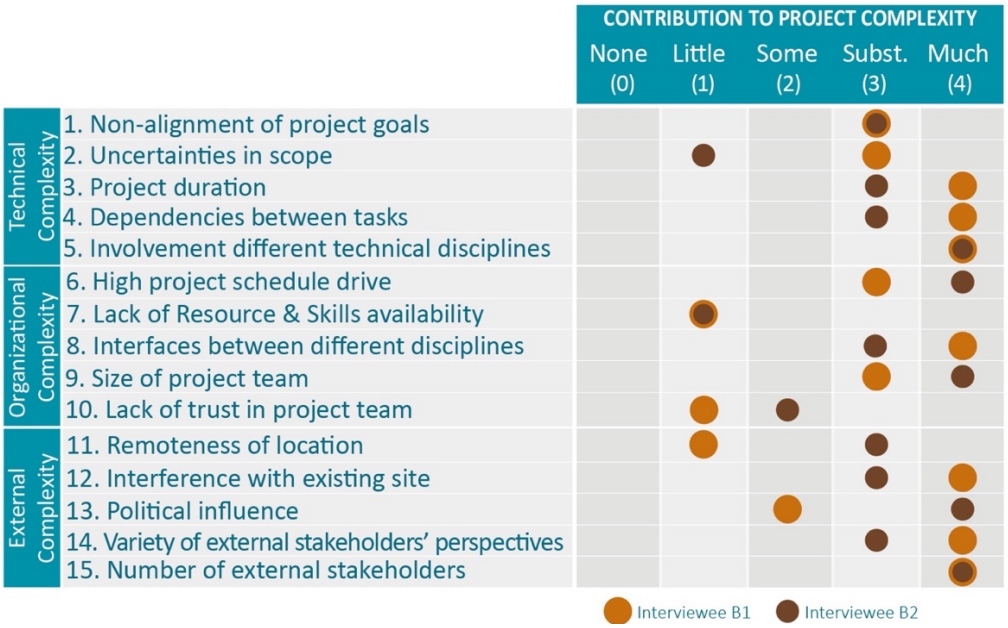


Figure 18 Complexity assessment of two interviewees of project 'Junction''

Technical complexity

Dependencies between tasks (4&3): Interviewee B1 indicates that a planning phase of such a project usually has many dependencies between tasks, making it complex. There was a lot of uncertainty and pressure on the dependencies between the tasks because the phases of contractor and plan executor ran parallel. This made it even more complex. In addition, interviewee B2 says that the client kept trying to expand the scope, which would entail that tasks already done should be redone.
Involvement different technical disciplines (5): Many different disciplines were present. Interviewee B1 says that they tried to manage those disciplines by grouping them into one overarching discipline. Interviewee B2 emphasises how many different disciplines were involved by explaining that the disciplines were involved from different phases of the project.

Organisational complexity

High project schedule drive (3&4): There was a high schedule drive from the client. Also, due to the MIRT the pressure on the schedule was high. Interviewee B2 indicates that the focus was on keeping the plan, and there was no room for delay.

"In the tender, there were all kinds of contract milestones that we had to meet. To be able to meet those milestones, we had to puzzle with planning in the tender phase. To make the planning fit the milestones, we had to make positive assumptions, and therefore there was little room for slack."

Quote of interviewee B1

Interfaces between different disciplines (4&3): Interviewee B1 indicates that many disciplines with many interfaces were present. Much attention has been paid to the interface. An interface manager was appointed to manage the interfaces, and with the team, they checked whether all the interfaces were known. Interviewee B2 states that the interface manager was necessary and valuable because everyone was responsible for their product and started working very hard on it, resulting in little time for the interfaces.

"Complexity is the multitude of people who have a task, and the task must be performed properly. You may cover the interfaces with a system and hire an interface manager for that. Still, pointing everyone to their responsibility and the interfaces remains complex with many people in such a large project."

Quote of interviewee B2

5.2.3 Project management approach

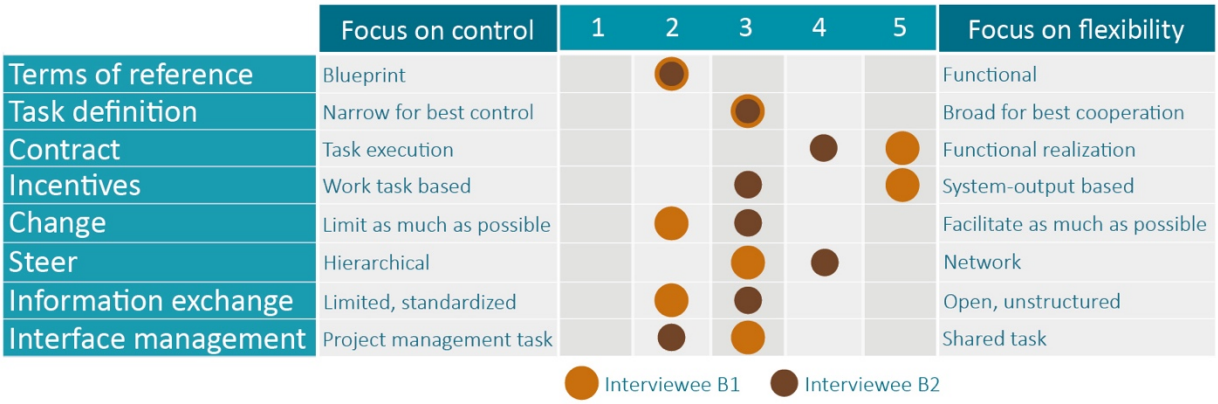


Figure 19 Project management approach assessment of two interviewees of project 'Junction'

The project management approach for project 'Junction' is average between control and flexibility with two outliers to flexibility from interviewee B1. The project management approach was estimated to be traditional, however, the approach tends to be little more flexible than traditional.

5.2.4 Flexibility

Flexibility in project management from the case

Serving interests and planning:

- In **collaboration meetings** at the start, it turned out the interest of the parties were far apart. First, all the **interest were inventoried, assessed, and prioritised** to deal with all those interests and looked at how we could deal with the relevant interests. Because this involved a large amount of money, it was elaborated at the level of the project director and examined how to deal with it. Next, it had to be **decided together in consultation**.
- The pilot for the contract form came with a new form of collaboration with different interests. To cope with the various interests, everyone was conscious of the fact, and they tried to **introduce phases** in which everyone focused **on their interests**. However, this turned out to be more complicated in practice, and the parties tried to serve their interest more along.
- Because phasing was not the only or best solution, a **weekly core team consultation** was held to discuss the interests. Then all the parties' interest were tried to serve and also the interests of the client.

Communication:

- Due to the integrality of the project and the overlapping phases, it was extra important to keep communicating about dependencies and keep the overview also on a lower level. Next to the core team consultation, **bilateral consultations** were held. This helped to keep (an integral) overview in such a large organization.
- Some requirements of the client were not feasible. To solve those requirements, the **dialogue was entered with examples** of requirements that have been set, the practical situation and what they tried and why they

are not able to fit it in. Then the **question was asked** whether it was possible to let go of the requirement or otherwise how they should deal with it.

- For environmental management, it is crucial to communicate with the environment. In this assignment, changes in scope were to be prevented due to limited money and time. A solution was to openly **inform the environment** to feel involved and supported the project but could not try to change too much. This was mostly done via a **digital EIA**.
- For keeping short lines and establish a team feeling, a **shared location to work** with the project team is desired. This worked well with the team of the assignment. For future projects, it would be preferred to also work with the client in one location.

Interfaces:

- There was an **interface manager,** and occasionally, there was a **bilateral consultation** with all project leaders to see if all interfaces were identified and controlled.
- **LEAN planning** also helped in identifying and managing interfaces. By consciously doing this with the different parties, it was possible to look beyond their disciplines and find out how to collaborate best to make maximum progress together. The conversation about what everybody needs helps to establish well-supported planning. This was done **in a room with 40 people with a planning board** and A0 sheets for planning at week level for the next half year. All the different parties of the project organization were present.

Flexibility enablers and project Junction

Flexibility enablers	B1	B2
Self-steering of the complete project team	±	−
Open information exchange among different groups	+	+
Shared interface management	−	−
Contingency planning		±
Seizing opportunities and coping with threats	+	+
Trust among involved parties	+	+
Standardise the process and design	+	+
Visualised project planning and progress	+	+
Possible alternatives		±
Network structure rather than hierarchical structure	±	±
Continuous learning	+	+

Figure 20 Attitude towards selected flexibility enablers of the interviewees from project Junction

Selected flexibility enablers

Self-steering of the complete project team (±&-): Both interviewees agree that self-steering of the complete project team is not desired in a large complex project like this, some structure is needed. Interviewee B2 states that there was too much self-steering in this project, with as a result, everybody did what they thought was essential, and the one with the biggest mouth was listened to.

> *"Different specialisms that work on such a project are very self-managing within their discipline. They know what they are capable of and what they must do to perform the task. Self-steering is about the content of your work and must fit into the overall project and planning."*
>
> Quote interviewee B1

Open information exchange among different groups (+&+): In the project, parties were present from various organisations. Interviewee B1 mentioned that every party had their own (working) culture, which meant that everyone differed in their degree of openness in communication. To get more aligned in the project organization in terms of communication, they invested in a joint project culture and rules for interacting. Also, interviewee B1 indicates that creating security to make yourself vulnerable to what you need is essential. Interviewee B2 explains that the system of the client and the project executor was the same, and they would have been able to see each other's system, but the capabilities to work with the system varied widely. Interviewee B2 states that an open system and knowledge are needed for the project, where the capabilities to work with it are present among the parties.

Shared interface management (-&-): For this project, there was one interface manager for the whole team, independent of which party you belong to. Both interviewees indicate that they find this valuable. In addition, meetings and shared interface management in sub-teams can help to map and control the interfaces.

Trust among involved parties (+&+): The interviewees emphasise trust was a critical aspect to invest in this project, primarily due to the form of collaboration. Interviewee B2 explains that there were sessions, meetings, cooperation rules, a barbecue and evaluation sessions to establish and maintain trust at the start of the project. Interviewee B1 says that with setbacks, everyone must be honest and then together look at a way to solve or cope with the setback. In addition, interviewee B2 states that it must be prevented that people from key positions in the project leave, which is important for the team and the knowledge, both contribute to trust in the group.

Visualised project planning and progress (+&+): LEAN planning was used to visualise and let people contribute to the planning. Both interviewees see this as a positive aspect. Interviewee B1 mentioned that this planning helped to interact and think along with each other as different parties.

Network structure rather than hierarchical structure (±&±): Interviewee B2 indicates that a network structure would contribute positively to the team spirit. However, both interviewees suggest that a network structure that is based on a hierarchical structure (management) would work best. In this project, an alliance form could have resulted in a more network-oriented structure.

Continuous learning (+&+): Interviewee B1 mentions that the core team consultations helped to continuously learn from each other as parties. In addition, reflections on construction and audits were carried out, peer review sessions were held, and evaluation moments were held internally and with the client. Both interviewees say that these moments of learning all together in one project was too much. Interviewee B2 recommends doing only a few learning moments because of the workload it also entails to do something with all those learning moments.

5.2.5 Flexibility webs

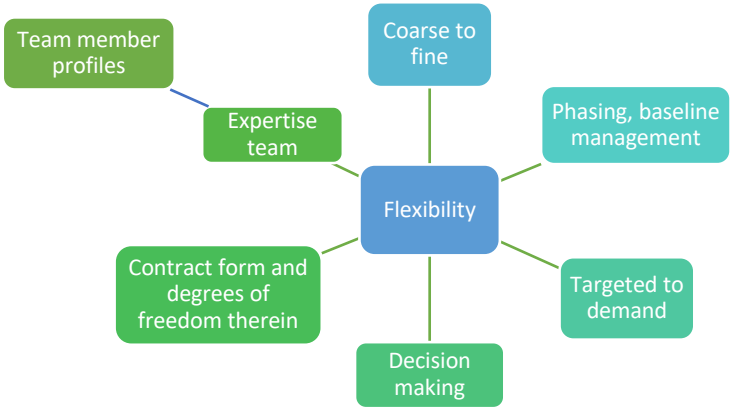


Figure 21 Flexibility web of interviewee B1 - EN

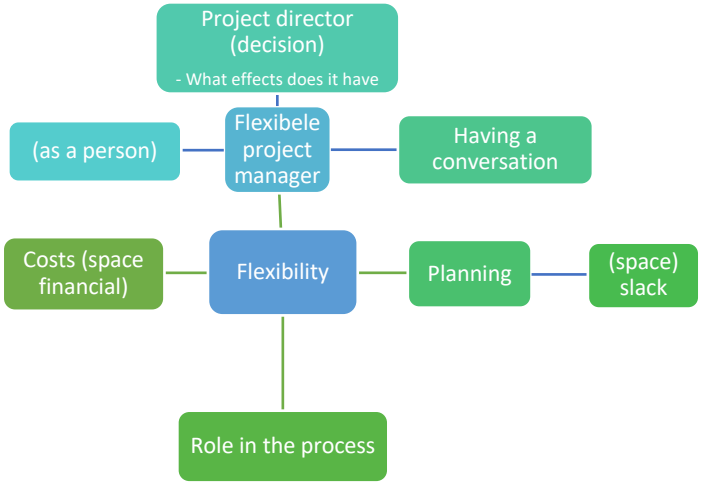


Figure 22 Flexibility web of interviewee B2 - EN

Interviewee B1 shows awareness of many different aspects involved in flexibility in project management. The aspects mentioned by interviewee B2 have less variation, they mainly focus on aspects in the circle of influence of the project team. In contrast, in the assignment the application of flexibility was explained to be limited by planning and costs. Still, different aspects of flexibility have been applied in managing the project. However, the contribution of the complexity elements to the overall complexity was scored high as not all complexity elements were managed.

5.2.6 Main findings

- Form of collaboration influences the effort needed to establish room for flexibility from the start
    - Different kinds of communication between the teams/participants help get an integral view of tasks and responsibilities, thereby enabling the project and giving the flexibility to manage the project.
    - Trust should be established for good collaboration and requires some focus.
- Working together in one location, keeping the communication lines short and visualizing the planning and progress brings people closer together. It makes it easier to get on one page, especially while working with different parties.
- Open information exchange/communication is a point of attention. On the level of having one system that all the parties can work with and personal.

5.3 Case C – 'Highway'

5.3.1 General description

Project:	Highway
Client:	Executive agency of the Ministry
Goal client:	Widening of the highway to reduce congestion and adapting the structures
Phase contractor:	Contract preparation phase
Budget project:	± €1,6 billion
Budget assignment:	± € 23 million (initial 8.8 mil.)
Project duration:	15-16 years
Duration assignment:	5 years
Main objective:	Contract preparation for the client and thereby: Providing quality services that match the substantive objectives and project ambitions of the highway project.

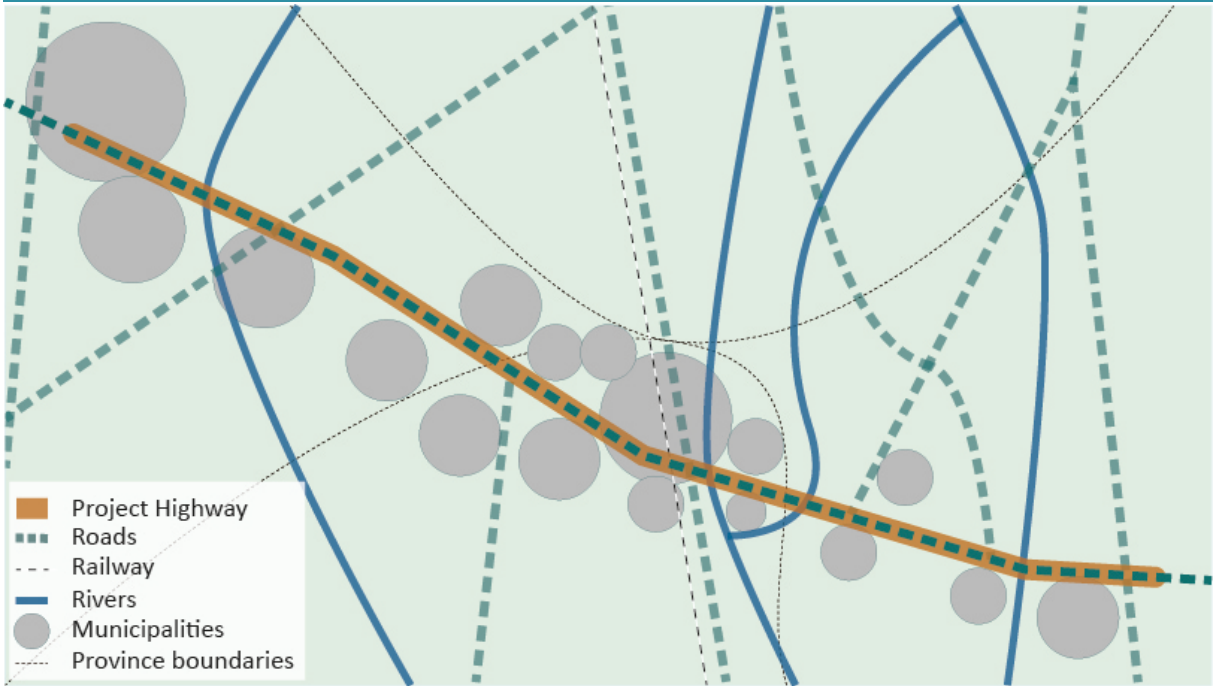


Figure 23 Abstracted map of project highway

Project Highway consists of the widening of nearly 50km of road and the renewal of the structures. The project is situated in three provinces and many different municipalities, affects various private lands, crosses several rivers and regional water authorities, crosses the railway, and is connected to several other roads (see Figure 23). Many stakeholders are involved due to the size of the project.

The project contains various specific tasks such as widening the entire road, adapting and replacing bridges, adapting junctions, dealing with the extra land that must be cleared and prepared and all the side issues that come with it.

In project Highway, the assignment for Arcadis was to prepare the contracts for and with the client. The assignment has a term of five years, during which Arcadis draws up the realization contracts and supports the client with the tendering process for these contracts. In addition, Arcadis also takes care of agreements with internal and external stakeholders.

To execute this phase of the project, a lot of different tasks needs to be done. First, the Customer Requirements and the scope are investigated what exactly they entail. Also, research, audits and controls are executed by Arcadis. Arcadis should manage this in terms of scope, planning, risks, finances, interfaces and information.

5.3.2 Project complexity

Project complexity in general

According to the interviewees, the overall project complexity is mainly a result of the project's scope. Due to the size, many different aspects are involved and related.
Manifoldness: As explained in the project description, the project involves a large road with many structures and many stakeholders and tasks.
Uncertainty: Especially at the very beginning, there was much uncertainty in the scope of the assignment. Also, in finding the 'right' team composition, there was uncertainty.
Interrelated parts: The project has parts with various interrelated functions, such as bridges and roads.
Interdependencies: On a larger scale, the functions of several areas come together. An example is the regional water authorities with the rivers and the bridges for traffic. These are all interdependent. On a smaller scale, many aspects/segments of the project have interdependencies. This is, for instance, due to stakeholders (perspectives), technical overlap, phase overlap, etc.
Non-linearity: In this large project, the project phases cannot be executed sequentially because there are too many dependencies. Every decision made has its consequences on the environment and vice versa.

Complexity assessment based on the TOE-framework

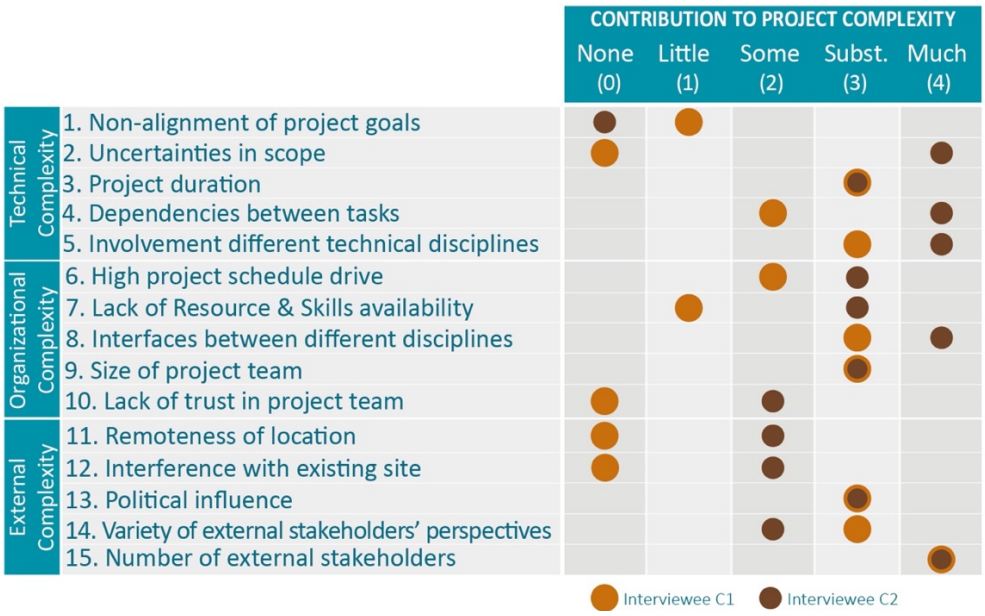


Figure 24 Complexity assessment of two interviewees of project 'Highway'

Figure 24 presents the assessment of the project complexity scaled by two interviewees from Arcadis's side. The scores of the project manager (interviewee C1) are given in orange, and the scores of the contract manager (interviewee C2) are shown in brown. The average score of the project manager on the asked complexity elements is 1,87, and the average score of the contract manager is 2,87, on a scale from 0 to 4. This overall difference can (partly) be explained by the period in which they were involved in the project. The project manager was hired later in the project when various matters had already been clarified.

Technical complexity

Dependencies between tasks (2&4): Both interviewees emphasized this element. However, C1 noted that this is an element that belongs to the profession and scored not as high as possible.

There were many dependencies between the tasks, parallel work packages, mutual relations and mutual cohesion. As the executor of part of the project, you depend on the other parts of the project and the client. For example, the planning phase ran partly parallel, resulting in the phases being intertwined, and Arcadis became partially dependent on the execution of the planning phase.

"With such a large project, it is difficult to oversee the integration of considerations continuously. You cannot approach things in a monodisciplinary manner. Everything is woven into something else."

Quote of interviewee C2

Involvement different technical disciplines (3&4): In Figure 23, it is partly visualised that many different disciplines are involved in the project. Also, due to the different types of work in the project, there are various disciplines for widening the road and the associated tasks and adjusting/renewing the structures. Interviewee C1 explains, for example, at the sections of the project with the waterways that there can be a widening of the road, but the requirements that come with the waterways need to be considered. These sections are where the road designer, the constructor, the nautician, the landscape designer, etc., need to work together and comply with the aesthetic program of requirements.

Organisational complexity

High project schedule drive (2&3): In the beginning, the central planning of the client was insufficient. Interviewee C2 mentioned that communication from the client was unclear, and they did not communicate at the correct level of abstraction for a long time. This resulted in not much was achieved, and quite a few milestones were missed. To conclude, the integrality of the planning was lacking. Because of the many dependencies and many different steps, it was challenging to make the planning clear for the entire team of the assignment.
Interfaces between different disciplines (3&4): There are many interfaces. The different interfaces that were addressed under the Technical complexity usually have interfaces. For example, at the sections of the project with the waterways, there cannot only be worked on widening the road, but the requirements that come with the waterways need to be taken into consideration. These sections are where the road designer, the constructor, the nautician, the landscape designer, etc. need to work together and comply with the aesthetic program of requirements.

The task of the interface manager was assigned to someone familiar with the project and involved in the tender phase. However, that person had also the role to step in wherever things went wrong and were, therefore, less in his supervision role of interface manager. There was a focus shift off interface management.

5.3.3 Project management approach

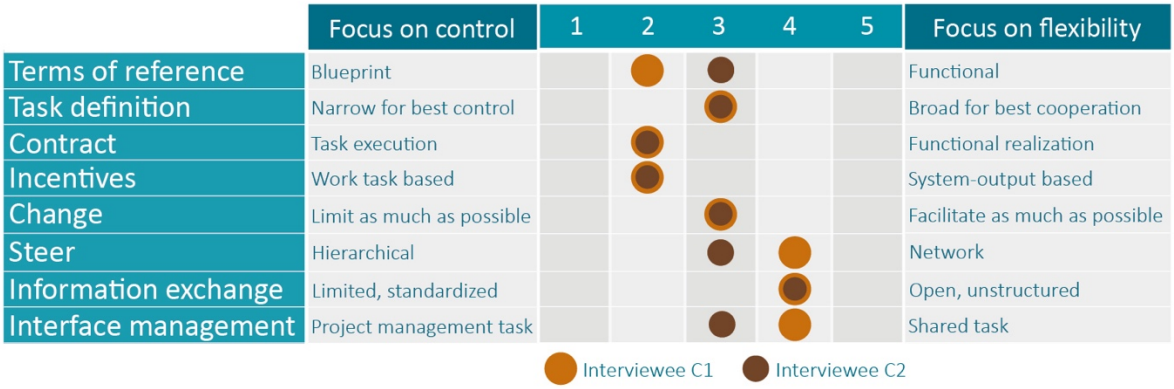


Figure 25 Project management approach assessment of two interviewees of project 'Highway'

Results show their opinions are primarily aligned and in between flexibility and control, see Figure 25. There are no extremes in project management. The score is somewhat symmetrical. The first four aspects score middle or slightly left to the centre, average but tend to control. The last four aspects score moderate or slight right to the centre, more to a flexible focus. The project management approach estimation was flexible. However, the project management approach tends to be more traditional.

5.3.4 Flexibility

Flexibility in project management from the case

Planning:

- Making the planning transparent for everyone proved very difficult during the project. The Gantt chart became more of a **flowchart** to make the sequence of steps clearer, to share the most important milestones and to show the main processes on an abstraction level that is interesting for everyone.
- Also, to keep track of the tasks, the planning and the most important milestones, the common thread of the assignment, **common thread sessions** were held. This was also important to fathom the project for the management of the assignment. The common thread sessions visualized that.
- In addition to the previous point, **sticker sessions** were held with all the different disciplines in the team to align with what needs to be done (for example, with environmental management, technology, project control)

Communication:

- The last two points from the planning led to new planning for the assignment, which could be **shared and communicated with the client** and could subsequently be integrated into the project's planning.

Interface management:

- The task of managing interfaces was a task that lost focus in the assignment. This was a learning point in the project and is a measure that could have a very positive impact on the project. It needs to be **one person** (per team) that is fully dedicated to the job.

Project team:

- When the wrong people are in the team, and they are not entirely trusted on the job. It is essential to **decide to replace or relocate** them. You cannot give everyone the same level of trust.
- Conversely, when people are good at the job, it is valuable to **respond to that and contribute to their development**. For example, this can be done by having them run with someone in another position. This allows them to grow and explore and thereby become more valuable.

Contract:

- The fixed sum contract implied the team having the finances in the back of their heads with all choices. This meant that there was reluctance in making promises and doing additional work because it costs time and money. **Changing to a directing contract** made the collaboration better. Then the whole problem disappeared, and customer satisfaction went up. Changing this is can be difficult, but the **conversation** is essential. The **acknowledgement that it is better for the project needs to be created.**
- There were two contracts for Arcadis for this project. One for engineering consultancy services and one for project control. The effect was that people behave according to the contracts and not according to the project. By becoming the **project manager of both contracts**, it was possible to **steer based on the work processes**. This resulted in a more integrated team, and the client appreciated it. However, this could not have been done at the start of the project with a strict scope.

Flexibility enablers and project Highway

Flexibility enablers	C1	C2
Self-steering of the complete project team	±	−
Open information exchange among different groups	+	+
Shared interface management	−	−
Contingency planning	−	+
Seizing opportunities and coping with threats	+	+
Trust among involved parties	+	+
Standardise the process and design		+
Visualised project planning and progress	±	+
Possible alternatives		+
Network structure rather than hierarchical structure	±	±
Continuous learning	+	+

Figure 26 Attitude towards selected flexibility enablers of the interviewees from project Highway

Selected flexibility enablers

Self-steering of the complete project team (±☹-): Interviewee C1 does think self-steering is an important aspect of complex projects. However, some level of the hierarchy is wished-for to keep the structure clear. Interviewee C2 finds self-steering less relevant because large projects need a system. Within the specific workflows of the project and in small projects, self-steering will probably positively contribute.

Open information exchange among different groups (+☺+): This enabler is seen as very important by both interviewees, not just among different groups but also within the team of Arcadis. Interviewee C2 indicates that there should have been more focus on planning and risk with the client. The client did do weekly planning board sessions at their office where the whole project team could join. At Arcadis, there was a weekly half-hour stand-up meeting with main topics as successes, plans, developments, changes, etc. These main topics were also communicated with the client. Between client and contractor was much communication. The interviewees emphasize the communication being open and accessible, which is necessary otherwise, you will lose people. The system to work in in a project is a point of attention in relation to complexity. Both parties

had their systems parallel to each other, which did not fully integrate and hampered the communication and sharing of information.

Shared interface management (-&-): Sharing interface management turned out very important in this project. The function of the interface manager must be deliberately facilitated, and it should be assigned to someone with solely that function.

The interviewees explain that both the client and Arcadis emphasized assigning a skilled interface manager to the project. Both managers should have their responsibilities, the client on the project level and Arcadis on the assignment level, and he/she must ensure comprehensive advice to the client. The interface managers should communicate together and discuss the shared interfaces.

Trust among involved parties (+&+): The interviewees see trust as an essential aspect in complex projects. Two kinds of trust are distinguished: contract-based and personal. Interviewee C2 mentioned a mutual lack of trust at the start of the project, partly due to the contract form. When the agreements for the contract changed, the trust increased. The personal kind of trust is whether you dare to be yourself with the other. The type of personal trust was present in the project from the start.

"Trust is an essential enabler. When there is no trust, little flexibility can be expected."

Quote of interviewee C1

Interviewee C2 says the client preferred to work together on one location. However, the client's location was very far for most people from Arcadis's side, and therefore there was a natural resistance to working there. Working together on one location would have helped to establish trust. Because it is vital that the client had the idea that Arcadis works on the project, does the right tasks and collaborates with the client.

Interviewee C1 states that you must make sure you fulfil your obligations and be honest and open to establishing trust. For example, when something does not work out or goes wrong, report it as soon as possible honestly to the client, including a proposal for a solution. Asking open questions and being available to the reaction is essential.

"Now and then, you make mistakes. Then you have to be open to the client and the consequences, and also want to learn from them."

Quote of interviewee C1

Visualised project planning and progress (±&+): Visualised project planning and progress are used in the project assignment. Interviewee C1 does not see this as something contributing fundamentally to the flexibility and sees it as a way of working. Interviewee C2 does see it as a flexibility enabler because a visualised planning made the project work tangible, despite working on different locations. The interviewee emphasises the importance of finding the right level of abstractness. To find the right level of abstractness, you need to have the right people on board to oversee the planning and process, structure and visualise based on experience.

Network structure rather than hierarchical structure (±&±): The method of the client tends to be hierarchical. The basis from the client was hierarchical, but at Arcadis, the approach was more network-oriented for the assignment. Interviewee C1 mentioned that the network structure promises itself to be subservient to flexibility. The interviewee does appreciate clarity utilizing a drawn hierarchical structure, but people should work together as a network in the work processes. Asking open questions is viewed as important and allow the people to take the initiative.

"Responsibility is placed with the individuals. Whom you give trust in their craftsmanship and to give them space to express their craftsmanship."

Quote of interviewee C1

A bit of self-management and self-reliance is certainly also important, but do not let go of your team completely:

"Comparison it to a shepherd: Herd walks in a certain direction by itself, but sometimes you have to give a little tap to the left and a tap to the right and take out the black sheep."

Quote of interviewee C1

Continuous learning (+&+): The interviewees mention there was not much emphasis on continuous learning. Interviewee C1 says it does happen, especially since the project is for a longer period, then a kind of organic

learning process emerges. The interviewees explain it is mainly based on experience, it is a learning process, and you take that with you. Interviewee C1 mentions that being open to making mistakes and the consequences and being aware of learning from them.

> *"Lessons learned will always remain a challenging point. You acquire particular experience. For those people who have been in the project, these are real learning points. But how do you transfer that to the organization? And how do you prevent those same pitfalls from being set again when you take on the same challenge with a new team? And if people from a new project know how to find the information, do they understand it? Is it pointy enough? Is it practical enough?"*
>
> Quote of interviewee C2

5.3.5 Flexibility webs

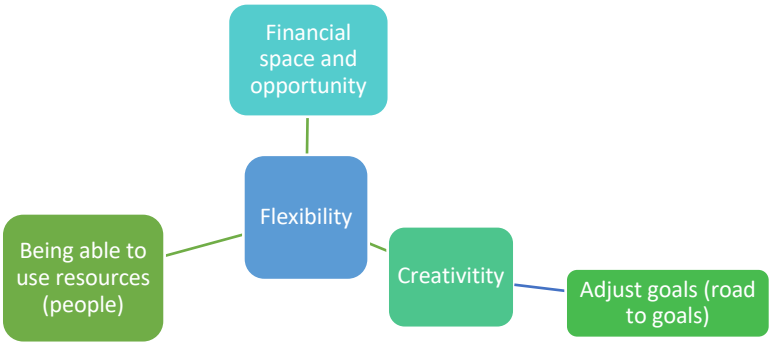


Figure 27 Flexibility web of interviewee C1 - EN

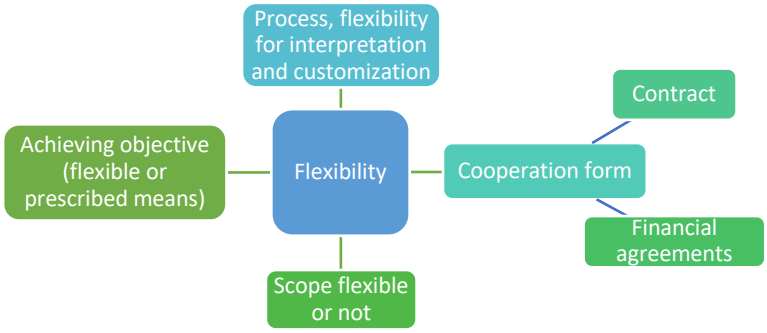


Figure 28 Flexibility web of interviewee C2 - EN

It is observed that interviewee C1 and C2 have a different view on flexibility at first instance, while related to the case, this view seems more aligned. Interviewee C1 works based on trust, while interviewee C2 prefers more structure. This is reflected in the webs by the simple, active and positive view of interviewee C1 and the more boundary related and passive view of C2. For interviewee C2 the flexibility is mainly bound and related to the agreements and requirements of the client.

5.3.6 Main findings

- The type of contract determines a certain degree of flexibility possible, from the start
  - Working attitude towards (goals of) client
  - Possibilities for seizing opportunities and coping with risks
  - Trust and communication
- Experience with similar projects provides flexibility
  - To have the right qualities and knowledge for the project
  - By being able to express the project on a more abstract level and to communicate that to the team
  - Through lessons that are learned individually
- Working together (on one location) as a project team with open communication and open information is important. (honesty, one system, linked systems)

5.4 Case D – 'Workshop for trains'

5.4.1 General description

Project:	Workshop for trains
Client:	Railway company
Goal client:	To build one central workshop for all different types of trains
Phase contractor:	Design phase
Budget project:	€ 150-200 million
Budget assignment:	€ 250.000
Project duration:	1 year and 2 months (would be longer, but the project is aborted)
Duration assignment:	5 months
Main objective:	Together with the client and other partners, a modular, sustainable and integral design for the workshop 'of the future' for trains will be made. This includes integration into the environment.

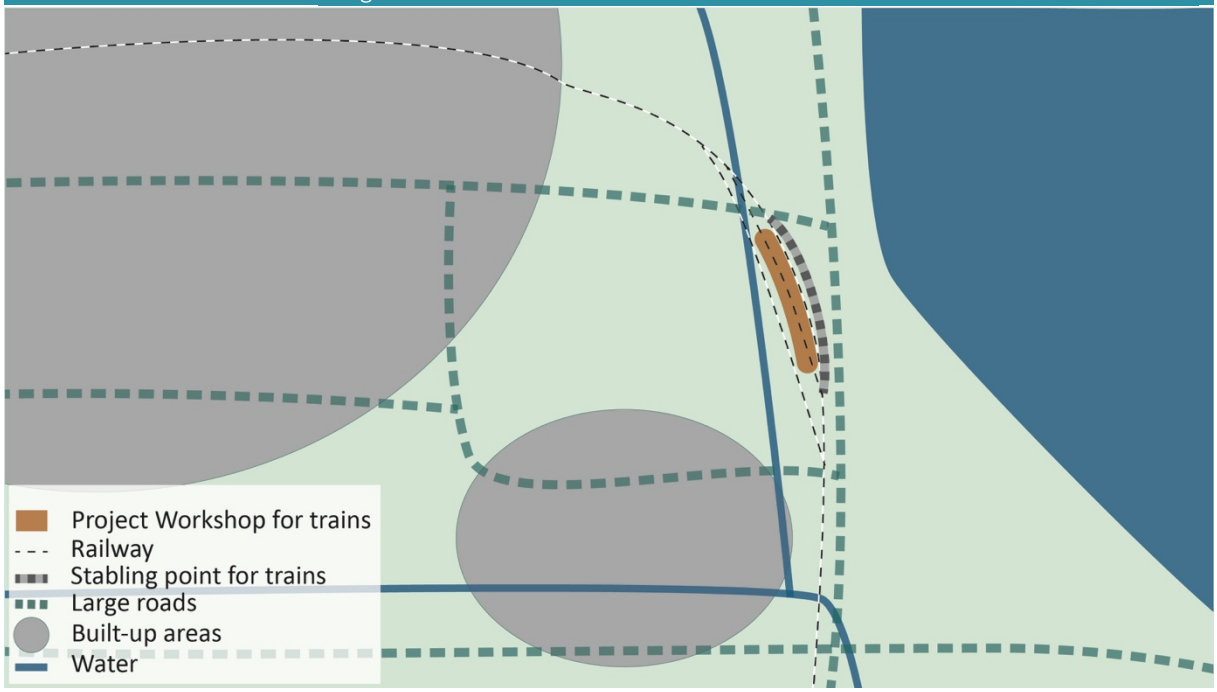


Figure 29 Abstracted map of project Workshop for trains

Project Workshop for trains consists of the design of a workshop where all types of trains can go for maintenance, modifications and repair on one central location. The project is situated in a greenfield between roads and railways and next to a stabling point for trains (see Figure 29).

The project has some specific aspects that make the project a real challenge, such as the versatile function of the workshop, connection to the road, storage location and the logistics around it.

In the project Workshop for trains, the assignment for Arcadis was to make an extensive preliminary design of the workshop together with two other parties. To execute this phase of the project, a lot of different aspects needs to be thought of. The preliminary design includes budget, progression planning, risk list of the rail infrastructure of the total site layout, connection to the main rail network and connection to the building to be realized. The design needs to be detailed, considering modularity, sustainability and integrality.

5.4.2 Project complexity

Project complexity in general

According to the interviewees, the overall project complexity is mainly a result of the interdependencies and interfaces in the project. The project's goal involves new technologies and tasks that (all together) have not been done before.

Manifoldness: Many different functions and tasks need to be brought together in a single design on a tiny project location.

Uncertainty: A project like this has not been done before. Therefore, it comes with many known unknowns and unknown unknowns. In addition, for all the functions that need to be combined in the design, it is uncertain how and whether it is possible.
Interrelated parts: The project consists of many interrelated parts. It is one large integral design that should consist of many possibilities to adapt to all the functionalities.
Interdependencies: Next to the interrelated parts, there are many interdependencies. Many disciplines are depended on each other and need to find an integral method to be combined and adapted to each function.
Non-linearity: Due to all the dependencies and interrelated parts, the project is non-linear. Only with an iterative process, the tasks can be matched.

Complexity assessment based on the TOE-framework

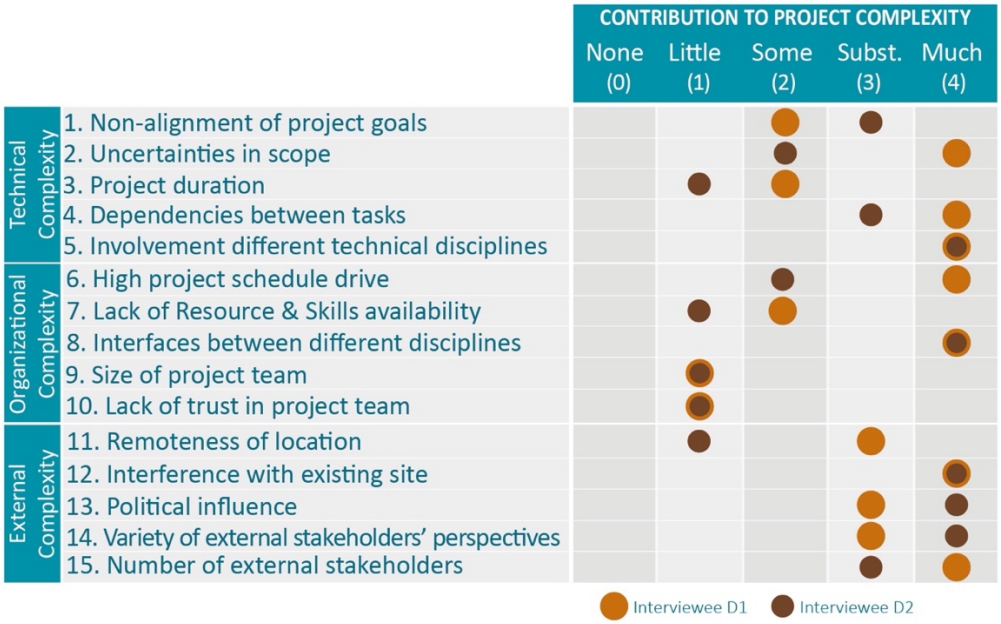


Figure 30 Complexity assessment of two interviewees of project 'Workshop for trains'

Technical complexity

Dependencies between tasks (4&3): It was an integral project with many dependencies. Many tasks had an overlap and had to be figured out together.

> *"Various aspects of the workshop design were intertwined. In a workshop, the track runs through the building, and the process that happens in the workshop has everything to do with the infrastructure that lies within it and, in particular, the infrastructure that lies outside it. There is much interaction between the building and the infrastructure, which makes it complex."*
>
> Quote of interviewee D1

In addition, interviewee D2 mentioned that everyone worked out their piece. Together in the studio meetings, it was communicated and checked whether this fits together.
Involvement different technical disciplines (4): Interviewee D2 emphasized the multidisciplinarity was mainly within the rail sector because many techniques were brought together in this project. Interviewee D1 explains that the client only had already eight different departments on the project. The workshop must provide an opportunity for all types of trains to be worked on. Interviewee D1 mentioned a railway operator was involved for a specific interface to get insight and more input, also in the points of attention. Interviewee D2 says that next to the disciplines within the rail sector, there were also other disciplines present, for example, for the accessibility of the workshop. The project location was small to fit everything in, and solutions had to be thought of the make everything work which resulted in involving other disciplines.

Organisational complexity

High project schedule drive (4&2): The client had given an exact term when the assignment should be completed. Interviewee D1 indicates that the client wanted to have it finished for a six-monthly evaluation session of their assets to gain insight into the costs. Interviewee D2 indicates that due to the workflow they had with the team, the work pressure did not feel that high.

Interfaces between different disciplines (4): Interviewee D1 states that many different disciplines were combined at the project location. There was much focus on the processes that should occur in the workplace, and whether they would not conflict with each other, everyone had to empathize with a different discipline. Interviewee D2 emphasized that all disciplines have interfaces in a small project location, challenging to fit all those interfaces.

5.4.3 Project management approach

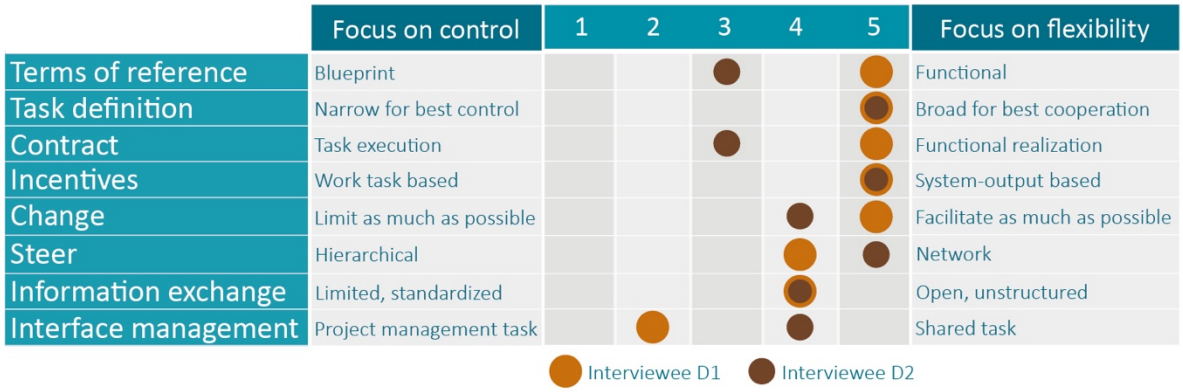


Figure 31 Project management approach assessment of two interviewees of project 'Workshop'

Both interviewees indicate the focus is on flexibility (Figure 31). In general, the project manager scores more focus on flexibility except for two outliers. The project management approach was estimated to be flexible, which seems in lines with the scores of the interviewees.

5.4.4 Flexibility

Flexibility in project management from the case

Communication:

- A principle used is **2x2 which means every two weeks 2 hours to sit together with the team in a design studio.** It is essential to keep a continuous flow in working together, sharing ideas, giving feedback and communicating and solving challenges and issues. In the sessions together, the endpoint needed not be set, and the focus was on the process. This also helps to keep the pressure off the planning.
- The visualisation was a critical aspect of communicating. Using short presentations, choices and options were visualised and presented. For the offer to the client, a PowerPoint presentation with visualizations was used.

Stakeholder commitment:

- To get commitment to the project from external stakeholders **communicating at an early stage** is important. Communicating with relevant parties and communicating to the public with a **press release** can be helpful.

Interfaces:

- To deal with the many interfaces and dependencies, it was necessary to **think and visualize three dimensions**. It also aimed at finding the right processes that are possible. This also helps to empathize with other disciplines.

Unknown areas:

- When new technology and processes came into the picture, **experts were brought in** to orientate towards possible solutions and to gain more insight into the risks

Uncertainties and collaborative design:

- Some solutions were not straightforward and required much attention. When a lot of creativity and space was needed to develop a good solution, they **worked from coarse to fine**. This can also be applied in the field of planning. First, big decisions should be made. This can, for example, weigh up by means of alternatives. This method worked well in combination with the 2x2 meeting set up.

Tender:

- The client largely facilitated flexibility in the project assignment by **asking an open question as a tender** and not a specific outcome/solution. For this kind of design assignments, flexibility must be stimulated.

Flexibility enablers and project Workshop for trains

Flexibility enablers	D1	D2
Self-steering of the complete project team	+	+
Open information exchange among different groups	+	+
Shared interface management	±	±
Contingency planning		−
Seizing opportunities and coping with threats	+	+
Trust among involved parties	+	+
Standardise the process and design	±	±
Visualised project planning and progress	+	±
Possible alternatives	+	
Network structure rather than hierarchical structure	+	+
Continuous learning	+	+

Figure 32 Attitude towards selected flexibility enablers of the interviewees from project Workshop

Selected flexibility enablers

Self-steering of the complete project team (+&+): Both interviewees emphasize the relevance of this aspect in the assignment. Interviewee D1 explained that in the offer to the client, they presented the team for the assignment as one team, as partners, where everybody is equal. D1 also explains that the client did come forward when something was not going as supposed to be. However, that rarely happened because they discussed all the steps in the assignment along the way.

Open information exchange among different groups (+&+): Also, for this aspect, both interviewees emphasized the relevance for the assignment and flexibilities in projects in general. Interviewee D1 clarifies that they had opened a site project site in OneDrive in which the parties had their folders. The lines between parties were short, and agreements were also made about how the team would communicate with each other and how we would deliver things to each other so that the other could continue.

"Share via a central medium. Everyone must have the same information at the same time."

Quote of interviewee D1

Shared interface management (±&±): The interviewees see shared interface as an essential aspect for the project's success and trust in the team. Interviewee D1 explains that they had a requirement control matrix drawn up at the start of the project, which consisted of the requirements from the client plus all requirements that emerged from the interfaces. Everyone had provided input for the requirements from interfaces. Arcadis was responsible for the task, but everybody was responsible for composing the requirements and verifying and validating the integral design based on those requirements during the project.

Trust among involved parties (+&+): Interviewee D1 explains that trust between the parties is crucial and starts with having trust in the project's success. In addition, communication and starting the conversation are essential aspects and needed when something is wrong. Trust was actively established through partnership agreements, getting to know each other and coming together with the team. In addition, interviewee D2 thinks of a kick-off (on project location) as an essential moment to start a project together as a team where all the starting points of the parties should be discussed. Next to that, the informal side is also essential to get to know each other.

Visualised project planning and progress (+&±): Interviewee D1 emphasized the importance of visualisation. For the sessions with the team, they communicated a lot in short PowerPoint presentations with visualisations. Also, visualising relations in a web from coarse to fine can help to discover interfaces. Interviewee D2 indicates that they used MS-project planning, which everyone could consult when desired but was not physically visible. However, the design was visible.

"The power of pictures is great. Making an image, a picture or drawing when something is complex can help a lot. That helps with zooming out and sparring with others."

Quote of interviewee D1

Network structure rather than hierarchical structure (+&+): Next to the self-steering of the complete project team, the network structure in the organisation was also seen as important by the interviewees. Interviewee D2 does note that the client had the final say. Interviewee D1 mentions that for a network structure for an assignment in an organisation, it is crucial that the organisation can facilitate that.

"You also have to be able to facilitate a network structure as organizations. That may not work within organizations with tight control."

Quote of interviewee D1

Continuous learning (+&+): There were no specific lessons learned sessions. However, there were learning moments on the agenda of meetings. Interviewee D1 explains that at each phase, they reflected on what worked and what did not. An example from a learned lesson is a system breakdown structure was a lesson learned of this project that they have taken to another project to visualise the project better. Both interviewees also indicate experience as a determining factor in getting a role in the project and bringing lessons learned back into the assignment and a future project.

5.4.5 Flexibility webs

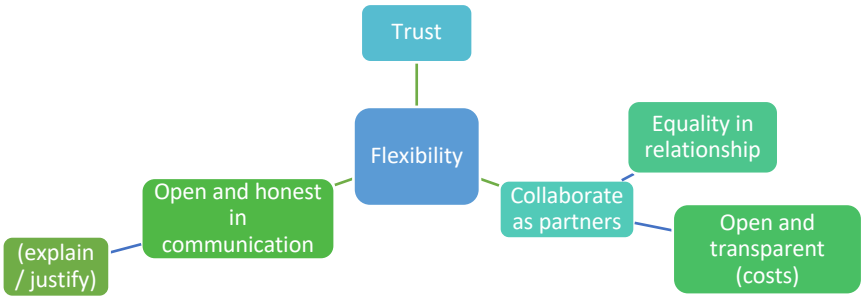


Figure 33 Flexibility web of interviewee D1 - EN

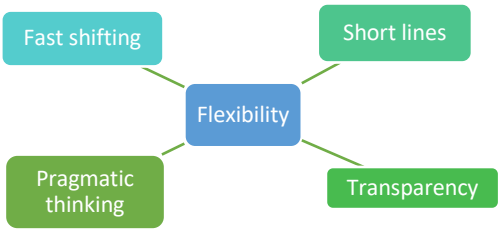


Figure 34 Flexibility web of interviewee D2 - EN

Interviewee D1 works based on trust, and the interviewee expresses that from the start. In the flexibility web of interviewee D1, all the flexibility aspects are related to trust and interaction between people. This is also reflected in the flexibility of the case. Interviewee D2 thinks more pragmatic, but the interaction between people is visible.

5.4.6 Main findings

- Winning a tender consisting of an open question gives much flexibility to execute the assignment/project.
- Good communication can facilitate flexibility
    - Open, transparent and visualized communication helps to be on one page and establishes trust among the involved parties.
    - Communicating and asking for help when needed is vital to keep moving forward.
    - Having regular meetings helps to establish a flow in which the team keeps working together.
- A network structure that builds on trust with appointed responsible people is a reasonable basis for an assignment/project.

5.5 Conclusion of the individual case studies

The individual cases help understand what complexities are experienced and how they are dealt with by flexibility. This helps to answer the second sub-question:

| SQ 2: How is flexibility currently incorporated in the management of project complexity?

In the case studies, it is found that flexibility is applied in various ways. For all four cases, this flexibility was related to communication and interfaces. For three cases, the applied flexibility was related to planning. Only the project with the most flexible management approach does not apply flexibility related to planning. It is observed that flexibility is often unconsciously applied by the project manager and the team in dealing with emerging complexities. The applied flexibility elements that the interviewees were not aware of are subtracted from the interviews and listed per case. The cases often address similar flexibility elements. The aspects that were discussed and applied consciously are coupled to the flexibility enablers and explained. Many operationalised flexibility enablers can be extracted from individual cases. Two main topics in drivers of flexibility seem to be 'working in a team' and 'personal experience'. In every case, these two topics are addressed in what is applied and related to applying the flexibility enablers.

From the flexibility webs, it can be concluded that project managers often see the need for flexibility to be included in the preconditions of the project. The flexibilities applied in the cases can most often be found in the daily aspects of a project. It is observed that project managers who work based on trust and interaction between people are perceived to conduct a more flexible project management approach in the first instance (estimation for projects C&D). However, the flexibility in the cases is determined by studying the flexibility elements applied and can deviate from the estimated project management approach (which turned out to be projects B&D). A cause of the difference in expectation and execution for the project management approach could be that the circle of influence for the project manager is limited for the project, which is partly determined by the contracts. The selected flexibility enablers are mainly perceived as positive even if they are partially applied.

6 Cross-case analysis

The cross-case analysis is divided into three parts. The first part contains the comparison of the results from the main subjects in the individual cases. The second part is about flexibility webs. The third part is about the relations between the variables of the cases. Lastly, the conclusion of the cross-case analysis is given.

6.1 Comparison of the cases

The topics from the research have been compared to get insight into the differences and similarities. First, the characteristics of the assignments are presented. Second, the project complexity from the cases is compared. Third, the project management approach from the cases is compared. Lastly, the flexibility discussed in the cases is compared.

6.1.1 Assignment characteristics

Cases A and D are assignments in rail projects, and cases B and C are assignments in road projects. An overview of the main properties of the cases can be found in Table 8. Next, the differences are briefly explained.

Table 8 Overview of the cases: type of client, phase, duration and budget

Case	Type of client	Phase	Duration	Budget (million)
A - Tram line	Public & Private	Design (final)	7 months	6.6
B - Junction	Public	Planning	7 years	5-8
C - Highway	Public	Contract	5 years	23
D - Workshop	Private	Design (initial)	5 months	0.25

The smallest of the four assignments is case D. This assignment is the smallest in all properties, such as the team of Arcadis, client, duration and budget. However, the project organisation for the assignment did consist of two more parties, and therefore the total of the assignment was more extensive than only the part of Arcadis. The parties worked together on the initial design of the project. Next project Tramline, the duration is only a few months longer than project Workshop, but the budget is more than 25 times the budget of project Workshop. The project client is public, but the client of the assignment itself is another engineering firm. Project Junction is the second largest project. The assignment has the longest duration due to many delays; the project was estimated at around five years. The scope of this project is considerable. The budget is about the same as project Tram line. The client of the assignment is public. The most extensive assignment is project Highway, with the largest budget, long duration and huge scope. The project is still in progress.

6.1.2 Project complexity

According to the respondents, all selected elements of the TOE framework (Bosch-Rekveldt et al., 2011) contributed to some degree to the project complexity. The category of technical complexity would be the least challenging (Bosch-Rekveldt et al., 2018). The findings of the four cases do not directly support this. In Table 9, the average of the scores for the category technical complexity is highest, next to external complexity and the organisational complexity scores the lowest for contributing to the project complexity in the cases. Important note: these scores are based on only 15 of the 47 elements of the TOE framework. They do not imply anything about the weighting of the elements in themselves for project complexity in general. For example, 'lack of trust in project team' (element 10 of Table 9) was emphasised by many interviewees as a possible main contributor to project complexity. In these cases, trust was established (to a certain extent). Therefore, this element did not contribute much to the project complexity. However, when the element would be present, the implications for the project and project complexity are estimated high by the interviewees. Therefore, element 10 is as important as a high scored element to consider in taking measurements to cope with them.

In Table 9, the selected elements from the TOE framework can be found with the degree of contributing to the project complexity in the cases. On average the elements 4, 5, 6, 8 and 15 contribute 'substantial' to 'much' to the project complexity. The elements 2, 3, 9, 12, 13 and 14 have 'some' contribution to the project complexity. The other elements 1, 7, 10 and 11 contribute 'little' to the project complexity.

Overall, there is a difference in scoring the elements over the cases. Case A does not have elements that contribute 'much' to the project complexity however various elements contribute significantly to the complexity (see Table 9). For case B, 'Involvement different technical disciplines and 'Number of external stakeholders' contribute much to the project complexity. 'Involvement different technical disciplines' also had a significant contribution to project complexity in other cases. 'Number of external stakeholders' has a significant contribution to the project complexity in three of the four cases. For case C, 'Uncertainty in scope' and 'Number of external stakeholders' contribute much to the project complexity. For case D, even three elements contribute much to the project complexity, which are 'Involvement different technical disciplines', 'Interfaces between different disciplines' and 'Interference with existing site'. 'Interfaces between different disciplines' has, in all the cases, a significant contribution to the project complexity. 'Interference with existing site' contributes significantly to the project complexity of two of the four cases. For the other two, the contribution is low.

Case B (and second case D) had the most dominant contribution to the project complexity from the selected elements. Case B has most elements contributing to project complexity, and case D had fewer elements, but on average, the contribution per element was higher. Only case A and C have one element contributing 'none' to 'little' to the project complexity.

Table 9 Overview of the cases: contribution of complexity elements to project complexity according to interviewees (scale 0-4)

	Technical complexity					Organisational complexity					External complexity				
Case	1. Non-alignment of project goals	2. Uncertainties in scope	3. Project duration	4. Dependencies between tasks	5. Involvement different technical disciplines	6. High project schedule drive	7. Lack of resource and skills availability	8. Interfaces between different disciplines	9. Size of project team	10. Lack of trust in project team	11. Remoteness of location	12. Interference with existing site	13. Political influence	14. Variety of external stakeholders' perspectives	15. Number of external stakeholders
A	1,5	2,5	3,5	3,5	3,5	3,5	2	3,5	3	0,5	1	1	2	1,5	2
B	3	2	3,5	3,5	4	3,5	1	3,5	3,5	1,5	2	3,5	3	3,5	4
C	0,5	4	3	3	3,5	2,5	2	3,5	3	1	1	1	3	2,5	4
D	2,5	3	1,5	3,5	4	3	1,5	4	1	1	2	4	3,5	3,5	3,5
Avg.	1,9	2,9	2,9	3,4	3,8	3,1	1,6	3,6	2,6	1,0	1,5	2,4	2,9	2,8	3,4
Avg.	2,95					2,40					2,58				

6.1.3 Project management approach

In Figure 35, the average scores of the two interviewees for the project management approach form can be found per case and aspect. In advance, the management approach was estimated to be a more traditional approach for case A and B and a more flexible approach for case C and D. From the table, only case D has a convincing flexible management approach for the assignment, and the other cases tend to an approach between controlling and flexible. Cases A and C are more to the control side of the project management approach. It has been observed that the boundaries of a project caused by the requirements of the client and contracts influence the flexibility that can be applied. For case D, the client tendered an open question that allowed the project management approach to be flexible. For case C, the contract changed during the project, which significantly impacted the flexibility that could be applied. Subsequently, the project manager plays a role in the application of flexibility. It could be that the expected flexibility approach was based on personal style. The project boundaries limit the circle of influence of the project manager within the projects. However, the variety that was tried to achieve between the management approaches of the cases is present.

The aspects 'terms of reference' and 'change' are the two aspects with an average score slightly towards the more traditional approach. These are also the two aspects where the difference in scores is the highest between the cases. The other aspects score more towards a flexible approach.

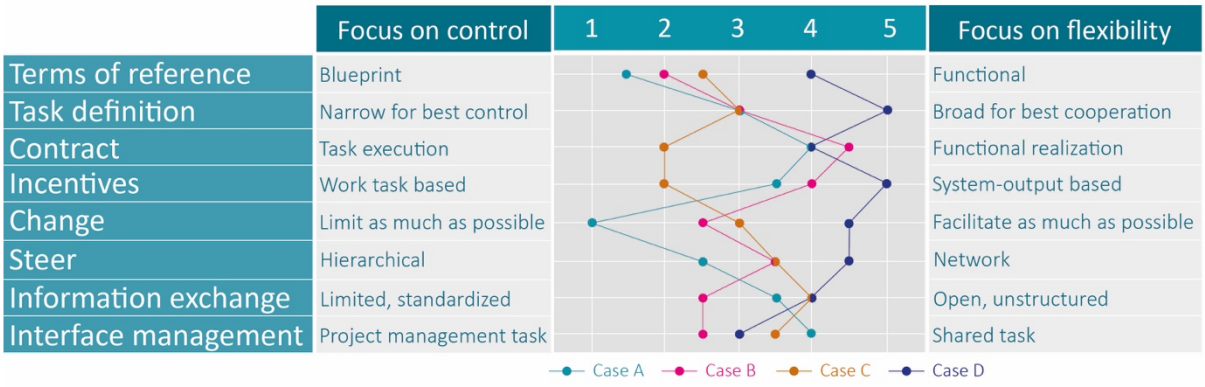


Figure 35 Overview of the cases: PM approach according to the interviewees (scale 1-5)

6.1.4 Flexibility

Flexibility from the cases

From the cases, some flexibility possibilities are more often used and addressed in the interviews than others. Next, the flexibility possibilities learned from more than one case are listed [number of cases (max 4) that addressed applied the flexibility aspect]:

- Honest and open communication [4]
- Extra meetings for collaboration and communication [4]
- Visualised communication (examples) [3]
- Online open communication [3]
- Employ experienced people [3]
- LEAN planning [2]
- Hiring experts in a field [2]

From these aspects, it can be learned that the applied flexibility (consciously or unconsciously) is about soft aspects such as communication, trust and people, and not about the boundaries of a project. This is logical since these aspects lie within the circle of influence of the project manager and can be performed daily. Project managers can also influence other flexibility aspects that are not mentioned (yet).

Flexibility enablers

All the interviewees had a predominantly positive attitude towards the flexibility enablers, see Table 10. 'Open information exchange among different groups', 'shared interface management' and 'trust among involved parties' is perceived by all interviewees as positive and relevant. 'Seizing opportunities and coping with threats' is often seen as common practice in the cases and mostly depends on the contract's content, sometimes seen as boundaries for flexibility. The interviewees do think of this aspect as relevant for flexibility in project management. Only for 'contingency planning' there were clear doubts in most cases. For some other aspects, the interviewees' opinions from the cases were also divided, but there was no clear opinion shown in the average score between the cases.

Some flexibility enablers are not supported for their content by the interviewees. 'Self-steering of the complete project team', 'shared interface management' and 'network structure rather than hierarchical structure' are explained differently by the interviewees to enable more flexibility throughout the whole project. In the individual cases, the interpretations of the interviewees can be found. The general interpretation is presented:

- Self-steering of the complete project team: Completely self-steering with just a supervisor would not work. An 80/20 ratio would be more appropriate. Self-steering for 80% in the team with 20% structure to manage the project and fit everything into the overall project and planning
- Shared interface management: Interface management as a shared task is not desired. However, interface management as a shared responsibility in the team with one person assigned to be the ultimate responsibility

for the interfaces and keep the overview is desired. Communication should be guided when necessary by the interface manager.

- Network structure rather than hierarchical structure: Based on a hierarchical structure (in baselines), a network way of working should be applied. Also, because (often) the client has the final say.

Table 10 Overview of the cases: application and attitude towards flexibility enablers

Case	Self-steering of the complete project team	Open information exchange among different groups	Shared interface management	Contingency planning	Seizing opportunities and coping with threats	Trust among involved parties	Standardise the process and design	Visualized project planning and progress	Possible alternatives	Network structure rather than hierarchical structure	Continuous learning
A	Partly	Partly	No	Partly	Partly	Partly	Yes	Yes	Yes	Yes	Partly
	±	+	-	±	+	+	±	+	+	±	±
B	Partly	Partly	No	Yes	Partly	Yes	Yes	Yes	?	Partly	Yes
	±	+	-	?/±	+	+	+	+	?/±	±	+
C	Partly	Yes	No	Partly	Yes	Partly	Partly	Yes	Yes	Partly	Partly
	±	+	-	±	+	+	?/+	±	?/+	±	+
D	Yes	Yes	Partly	No	Yes	Yes	Partly	Partly	Yes	Yes	Partly
	+	+	±	?/-	+	+	±	±	+/?	+	+

A slight difference can be found in the attitude towards flexibility enablers and the applied flexibility enablers (Table 10). For the first three cases, the project manager (±) and the other interviewee (-) score different on the 'self-steering of the complete project team' while applied to some extent. It might be that the project managers see the positive side of self-steering while the team prefers clarity in the team structure, perspectives can make a difference. Only for case D, both interviewees agree, and self-steering is applied. Open information exchange is an aspect everybody finds important for flexibility but is not fully applied in cases A and B. This is due to different reasons, but it was emphasised to have open information exchange by an integrated system of one system in both cases. For 'trust among involved parties', there are also minor differences. For the cases, this can mainly be explained by a limited trust in the client due to different reasons.

Four out of the eleven selected flexibility enablers are chosen to elaborate further. The chosen flexibility enablers are 'open information exchange', 'trust among involved parties', 'visualised project planning and progress' and 'continuous learning'. These flexibility enablers are chosen because the interviewees repeatedly emphasise them to be essential for coping with project complexities. In addition, these flexibility elements were linked to project complexity in several ways in the individual case study, indicating their effect on coping with multiple complexities. The four operationalised flexibility enablers from the case are presented in Table 11. The complete list of operationalised flexibility enablers can be found in Appendix G.

Table 11 Selected flexibility enablers operationalised

Flexibility enabler	Operationalised
Open information exchange among different groups	• An integrated system with the project team • The project site in OneDrive • Weekly sessions with the team • Establishing a common project culture and rules of how to interact • Creating the security to be vulnerable • Communication with the client regularly • Creating short lines between the parties by regularly communicating • Agreements on how to communicate and how to deliver things to each other

Trust among involved parties	• Cooperation coach
	• Kick-off with informal and formal part (on project location)
	  ○ Discuss starting points
	• Establish cooperation rules
	• Regular meetings
	• Prevent people from key positions leave, for knowledge and team
	• Work on one location with the project team
	• Fulfil obligations and be open and honest when something does not work out, report as soon as possible, including a proposal for a solution
	• Asking open questions and being open to the reaction
	• Make sure there is confidence in the project
	  ○ Change agreements for the contract when needed, make it a topic of discussion
	• Communication and start the conversation when something is wrong

Visualised project planning and progress	• LEAN planning on the wall
	  ○ Combined with a daily stand to discuss progress
	• Get the right people on the team for managing planning and process, structure and visualize based on experience
	• Visualised communication
	  ○ Presentations (PowerPoint)
	  ○ Use visualisations
	• Visualise relations in a web or breakdown structures (helps discover interfaces)
	• Design visible

Continuous learning	• Know who is needed on the team (based on knowledge, via others and get to know people) • Balance in experience in the project team (enough experienced people) • Evaluations (between phases, between milestones, peer review, moment for in each meeting) • Construction reflections • Learning trajectory for inexperienced with the experienced

6.2 Flexibility webs

In each interview, a web of words was created of the interviewee's view on flexibility in the management of complex projects to understand the perception of flexibility (unrelated to the cases). The following elements were addressed by the interviewees [number of interviewees that addressed the aspect (max 8)]:

- Decision-making and communication [4]
- Financial space and transparency [4]
- Collaboration form [4]
- How to deal with changes [4]
- Achieving goal/objective flexible [3]
- Resources/expertise present [3]
- Planning with slack [3]
- Contract form [2]
- Organisation and process [2]

Elements that were addressed once are not included.

In the flexibility webs, the emphasis is on the boundaries of a project, such as the project agreements that should allow more flexibility. It is observed that in most cases the actions of the interviewees are not corresponding to their flexibility web. In practice, it was found that for applied flexibility, the emphasis was on aspects within the project such as trust and communication and not on the boundaries of a project. It is valuable that the application of flexibility will be more in line with the view on flexibility. Therefore, it is necessary to create awareness for all perceptions of flexibility to make supported decisions about the implementation of flexibility. 'Practice what you preach' and, even better, increase knowledge to be knowledgeable in what you preach.

6.3 Exploring relations between the variables

In this section, a comparison is made between the subjects of the cases, including the relations. The following four relations will be analysed, first, between project complexity, characteristics and management approach. Second, between complexity and flexibility from the cases and enablers. Third, between management approach and flexibility from the cases and enablers. Final, between flexibility webs, flexibility in the cases and the flexibility enablers.

6.3.1 Relation between project characteristics, project management approach and project complexity

Case D seems, on average, the most complex and has the most flexible project management approach. Case B also tends to be more complex and has a slightly more flexible than controlling management approach. The project characteristics highly differ.

Case D is the only assignment with a private client and has the most convincing flexible management approach. The interviewees explained this relation in combination with the open question the client asked as the facilitator to a more flexible management approach as a reaction to the project complexities. The interviewees mentioned that a public client is not able to ask for an open question in a tender instead of a defined goal and scope because of regulations and organisational structure. For case C, the contract changed during the project, which caused fewer limitations and more collaboration. This influenced the flexibility possible to apply positively. However, whether the question from the client is the direct relation cannot be said based on the cases, also because the phase and budget also differ. It is observed that the contracts and requirements make a big difference and can limit the circle of influence, also for applying flexibility, of the project manager.

Almost all interviewees mentioned interface management as an important aspect. In Table 9 can be found that 'interfaces between different disciplines' contributed significantly to the project complexity for all cases. Figure 35 presents an average to flexible score for the project management approach for the cases. Note: case A seems to have a relatively high score, but the interviewees explained the aspect to have a similar meaning as the other interviewees explained.

6.3.2 Relation between project complexity and flexibility

All cases scored high on the complexities 'Dependencies between tasks', 'Involvement different technical disciplines' and 'Interfaces between different disciplines'. These were also the complexities indicated by the interviewees as important for contributing to project complexity. All interviewees linked these complexities to aspects for managing information exchange, interface management and trust in the project team that are important to cope with those complexities. These flexibility aspects can be linked to selected flexibility enablers 'Open information exchange among different groups', 'Shared interface management' and 'Trust among involved parties'. The themes of these flexibility enablers were found relevant for coping with the complexities. However, the flexibility enabler 'Shared interface management' is explained to be different from the flexibility enabler of (Jalali Sohi, 2018) and is therefore scored low for the enabler itself. In addition, the interviewees emphasized the relationship between the individual complexities and between the flexibility enablers. The interviewees coupled all these complexity elements to interfaces and interface management.

Almost all cases scored high on 'High project schedule drive' and 'Number of external stakeholders', but only for the element 'High project schedule drive', a relation with flexibility is found. The relation is found in the flexibility webs that often referred to planning. In addition, the relation of 'High project schedule drive' with operationalised flexibility elements is found in the individual cases.

Within the scores of the complexity elements, there can also be a relation found. Cases B and D score relatively higher than cases A and C, especially case D scores higher. The cases with higher complexity scores could have been more complex. However, these are subjective elements since these are scored by the interviewees based on a selection of elements.

6.3.3 Relation between management approach and flexibility

The project management approaches were indicated to be different from the approaches applied in the cases. Cases A and B were indicated to be more controlling in the project management approach, and C and D were more flexible (see Figure 35). Case A, B, and C scored in between a controlling and flexible focus for the project management approach. Of these three cases, only case B tends to be a little more to the flexible side. Case D scored to have a flexible focus for the project management approach. In Table 10 can be found that case D is applying the most flexibility enablers, and case B is also applying slightly more flexibility enablers than cases A and C. It is observed that the project managers who were estimated to have a more flexible project management approach in the cases focused more on relational aspects and trust in expressing flexibility in the webs. However, in the execution of the assignments, the project managers were limited in applying flexibility by the conditions of the project. It could be that contractual limitations in case C limited the opportunities to apply flexibility. Also, it could be that inspiration for operationalising flexibility could help to extend the application of flexibility and let all project managers be more flexible in approach.

The cases score similarly on aspects of the project management approach and the attitude towards/applied flexibility enablers. These elements seem to have overlap. For example, 'task definition' and 'steer' of Figure 35 and 'self-steering of the complete project team' of Table 10. Also, 'change' of Figure 35 and 'seizing opportunities and coping with threats' of Table 10. Next, 'information exchange' of Figure 35 and 'open information exchange among different groups' of Table 10. Lastly, the 'interface management' of Figure 35 and 'shared interface management' of Table 10 also have the same kind of relation, while this is not visible in Table 10. This relation is not visible in the tables because the interviewees see shared interface management different than the explanation of the flexibility enabler.

The other elements of the project management approach 'terms of reference', 'contract' and 'incentives' can be perceived as preconditions that refer to the requirements in the tender and the contractual agreements. These are not directly related to the selected flexibility enablers but might contribute to slack in the project. Slack can give room for flexibility, for instance, in terms of planning, risk management, alternatives, meetings, creativity, etc. These options for flexibility can be found in the individual cases under the sections 'flexibility in the case' and 'flexibility enablers'.

An explanation for the differences between the project management approaches (Figure 35) and the attitude towards flexibility enablers (Table 10) could indicate that the interviewees prefer more flexibility. However, the project (preconditions) does not always allow for that. In addition, the interviewees' personality also played a role in the attitude towards flexibility enablers, while this is unrelated to the project management approach in the project.

6.3.4 Relation between flexibility webs, flexibility in the cases and flexibility enablers

In the first instance, most interviewees focus on practical aspects and, to a lesser extent, on soft factors. Aspects such as trust, collaboration as partners and being open and transparent are only mentioned in case D, which is most positive on flexibility enablers. The intangible aspects of the flexibility enablers are rarely addressed in the web on flexibility by the interviewees, aspects such as trust, continuous learning and experience, which are often emphasised aspects while discussing the flexibility enablers. The four operationalised flexibility enablers are enablers for the aspects that project managers often do not think of in the first instance.

The flexibility webs reflect the perception of the interviewees. It can be concluded that their view is often related to organisational agreements of projects. In contrast, the flexibility from the cases shows flexibility is applied by using aspects not directly linked to the project's agreements. Examples of those applied aspects are communication, collaboration, team composition, visualising and contributing to the planning and hiring external when needed. This could imply two things. The interviewees are aware of how they can apply

flexibility despite the restrictions imposed by the set boundaries and are looking for flexibility options for making the boundaries more flexible. Alternatively, the interviewees can apply the flexibility in the cases without being aware that applying these aspects consciously can help overcome project complexity and think that reducing restrictions enables more flexibility. These two theories are never entirely true or false, and flexibility is relevant for both fields: within and outside the set boundaries.

The flexibility enablers emphasized by the interviewees and assessed positively to cope with complexity have been applied to some extent (Table 10). However, there is more potential for these flexibility enablers to cope with complexity. These applied flexibility from the cases matches the list of the four operationalised flexibility enablers.

All the cases together give a large set of operationalised flexibility enablers. The individual cases could learn from the collected operationalised flexibility enablers to strengthen areas they fall short and see what they should keep doing. It also applies that it must be assessed what operationalised flexibility enablers will and will not be suitable for a specific project through experience.

6.4 Conclusion of the cross-case analysis

The cross-case clarified where flexibility is needed over the cases and explores which flexibility enablers can be used to cope with the complexity. This helps to answer the third sub-question:

| SQ 3: What are the opportunities for incorporating flexibility in the management of project complexity?

With clarification of the relations between the cases, it is found that four complexity elements contribute substantially to the project complexity for all cases. In addition, these elements are also emphasized by the interviewees as relevant complexity elements. The first three elements are considered significant because the elements are interrelated. The four complexity elements are:

1. Dependencies between tasks
2. Involvement different technical disciplines
3. Interfaces between different disciplines
4. High project schedule drive

Seven flexibility enablers are emphasized to be important and/or have been scored positively for attitude and application:

1. Self-steering of the complete project team
2. Shared interface management
3. Network structure rather than hierarchical structure
4. **Open information exchange among different groups**
5. **Trust among involved parties**
6. **Visualised project planning and progress**
7. **Continuous learning**

Of the seven flexibility enablers, the first three are emphasised to be essential elements even if they are explained to be different in their contribution to more flexibly project management. The three elements are 'Self-steering of the complete project team', 'Shared interface management' and 'Network structure rather than hierarchical structure'. These three enablers were explained to allow for more flexibility in the project under the condition that these elements require some structure.

The last four elements are coupled to coping with project complexity in management and were operationalised in the cases (the comprehensive list of selected operationalised flexibility enablers can be found in Table 11). Therefore, these last four (**bold**) elements are used to develop a more flexible project management strategy.

No one-to-one relations have been distinguished between complexity elements and flexibility enablers. However, relations have been found between multiple complexity elements and multiple flexibility enablers. The first three complexity elements are linked to flexibility enablers 4,5 and 6 and are emphasized to affect the management of project complexity positively. The element 'continuous learning' is explained to affect many of the complexity elements positively.

7 Development of the tool

7.1 Initial tool

In the cross-case, it became visible that certain elements of the TOE framework and the selected flexibility enablers were considered more relevant for coping with complexity by means of more flexible management. The case study illustrated that the willingness to manage more flexible is high, and awareness of options is needed. A tool has been developed to make project managers aware of certain complexities and start working on implementing flexibility enablers. The initial tool can be found in Appendix I. The tool is based on the Flexible project management framework of Jalali Sohi (2018) (Figure 36). The tool is meant for project managers aware of their project being complex and who are willing to make the project management more flexible to cope with the complexity. Due to the scope, the tool will not cover all complexity and flexibility aspects.

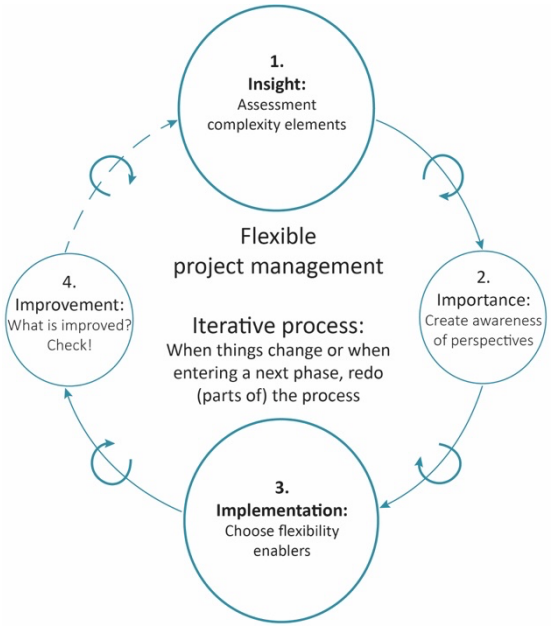


Figure 36 Flexible project management framework adjusted for tool

Step 1. Insight: assessment complexity elements

The first step is to gain insight into the complexity of the project. Based on the cross-case analysis, the selected complexity elements are: 'dependencies between tasks', 'involvement of different disciplines', 'high project schedule drive' and 'interfaces between different disciplines'. In this step, it should be analysed whether these complexities contribute to the project complexity, and when they are, the boxes should be checked in the tool.

Step 2. Importance: create awareness of perspectives

The research shows that there are different views on flexibility in managing complex projects. Jalali Sohi (2018) explains that for the project team, it is important to understand which perspectives on flexibility exist. By making these perspectives explicit, i.e., by creating word webs on flexibility and knowing what is felt necessary for the project, it is possible to choose the flexibility enablers supporting collaboration.

Step 3. Implementation: Choose flexibility enablers

For this research, 11 flexibility enablers have been selected to research throughout four projects. Research showed that the interviewees positively assessed four flexibility enablers, showed a relationship with the selected complexities and were operationalized in the projects. The flexibility enablers have been retrieved from the individual cases and are listed (see Appendix H for the complete list). These flexibility enablers can be selected to be applied in project management for coping with complexity.

Step 4. Improvement: Check what is improved!

There are many possibilities to make project management more flexible. The idea of being more flexible is not to stick to one specific enabler but to communicate and to the consequences of taken actions and to what is happening in the environment. Therefore, it is essential to evaluate previously taken actions. Do they give the expected results, or are other actions needed? This step is considered essential to stay flexible and to be able to keep improving the project management. Experience is a key, and we can only experience by trying!

7.2 Expert consultation

To evaluate the flexible project management tool on the usability of content and form an expert consultation is held online with project managers. In preparation for the consultation, the initial tool (Appendix I) is shared with the five participants. In the session, a presentation was given on the performed research, including the tool. Subsequently, the experts have been asked to score elements of the tool on usability for content and layout. Lastly, the experts have been asked to explain their view on the tool, per element and in general, and discuss it in the group of experts (all comments can be found in Appendix J). The session's outcome was used to further improve the tool and discussion on implementing the tool in practice. The assessment of the tool and comments to include and not to include is presented last.

7.2.1 Assessment of the tool

The online expert consultation included an anonymous scoring of the tool. This gives the experts the freedom to score what they think and prevents influencing each other's scores. An online evaluation form was set up and shared during the expert session. Experts could rate the specific elements and the complete tool step-by-step. The scores are presented in Table 12.

Table 12 Opinion on the initial tool for the usability of content and form by the five experts (scores: strongly disagree 1-5 Strongly agree)

	ID	Exp. A	Exp. B	Exp. C	Exp. D	Exp. E
1. Assess complexity	*Content*	4	4	4	3	4
	Form	4	4	4	3	3
2. Create awareness	*Content*	3	5	3	4	3
	Form	5	5	2	5	4
3A. Select flexibility enablers	*Content*	4	4	5	3	4
	Form	4	4	5	3	3
3B. Select operationalised flexibility enablers	*Content*	3	4	5	4	4
	Form	3	4	5	4	4
4. Check	*Content*	3	4	3	3	3
	Form	3	4	1	4	3
Tool	*Content*	4	4	3	4	3
	Form	4	4	3	4	4
	Connection to project management?	5	4	3	4	3

7.2.2 Comments included and not included

The selection criteria for taking in the comments are the consensus of the experts in the discussions and what the researcher considered relevant. The experts were optimistic about the tool and the focus on flexibility in project management. The experts saw added value in the tool. The experts were critical and looked at the tool from different perspectives, making their input very useful. The experts did have some comments for all steps of the tool. In general, they agreed on the minor points of improvement. Expert C (Table 12) shows two outliers. In the discussion on these subjects, points of improvement were clarified supported by the other experts. The fourth step of the tool was scored neutral on average, and the expert agreed improvement was necessary for better use of the tool. Considerations were made to make the tool useful and supported by literature, the addition of the element 'others' in 3B has been justified by referring to the extensive list of operationalised flexibility enablers and the iterative nature of the tool, which secures the improvements over the process of using the tool. The comments included in the final tool are presented and explained in Table 12. The comments that were not included are presented in Table 13. The final tool is presented in paragraph 7.3.

Table 13 Comments of the experts that are used to improve the Flexible project management tool.

Step	What?	Why and where in the tool?
Tool	• When should you use the tool? • Include/involve the client in the steps of the tool	• Added for insight, in the intro of the tool • For clarity, in the intro of the tool and the explanation
1. Assess complexity	• An explanation for the selection of complexity elements	• Consensus in group and makes it more explicit, added to the explanation of the step
2. Create awareness	• Suggestion: it could be part of the kick-off • Showing options for creating a word web	• Good suggestion and fits the research added to the explanation of the step • Good to give suggestions that make it easier to complete the step, in explanation of the step
3A. Select	*No comments*	*No comments*
3B. Select	• The addition of 'others' to stimulate finding project-specific flexible solutions • This is the value of your tool	• Flexibility is also needed to optimise the use of the tool for individual projects, 'Others' is added to the list of 3B. The list of appendix H can be used for additional project-related enablers. • Emphasis is important, stays focus point
4. Check	• Add a "who" and "how" to the explanation of step four to make it more explicit • Add a checkbox to step 4 to plan a reflection moment	• Both comments: this tool should motivate to do all the steps, and this makes it more evident and in line with the rest. The first comment is included in the explanation and the second in the step of the tool.

Table 14 Comments of the experts that are <u>not</u> used to improve the Flexible project management tool

Step	What?	Why?
Tool	• The next step could be to set up the operationalized 'flexibility enablers' of the tool in a modular way. Then you can choose the modules and use them right away, which saves time and effort. • Accessibility of the tool in the online environment of Arcadis should be considered. • Arcadis must be careful not to have too many of those kinds of collaboration tools on projects because then the information will be in different tools, but that is something beyond this session	• This is a nice feature but due to limited time, this is not feasible to look at. This is a good idea for practical implementation within Arcadis. • Goes beyond this thesis. • This tool makes it easier to include flexibility in a project, other options are also not desired. In projects, it should be strategically integrated to not be overloaded with tools.
1. Assess	*No comments*	*No comments*
2. Create awareness	• Shadow list with flexibility options • Distinction with risk session	• To avoid bias and steering this is not included • Could be presented/explained/marketed but should not be part of the tool.
3A. Select	• Name change of 'High project schedule drive'	• Opinions differ too much, does not seem necessary
3B. Select	• 'One project site' can be done in teams, • Risk pot (open pot with the client) • Explanation of the terms is not taken in. • Not all elements are suitable for every project, it is good to know when enablers can be applied and when enablers are suitable or not suitable for the project.	• Not taken in because of lack of knowledge about this and not everyone seemed to support it. • Could be a good recommendation but is not supported by my research for these complexity elements. • The tool is in English but could be translated to Dutch for projects executed in solely The Netherlands. • This is very interesting for expansion of the tool but not taken in the tool due to time limitations. However, the most important notions are given in the tool.
4. Check	*No comments*	*No comments*

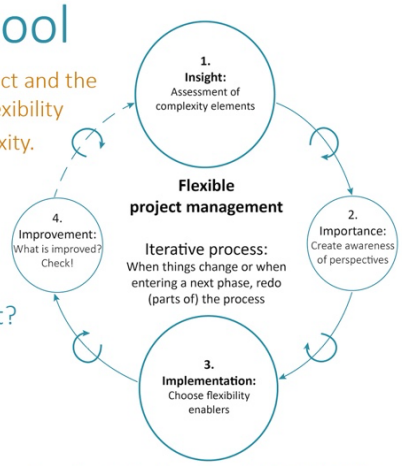
7.3 Flexible project management tool

The flexible project management tool is presented based on the draft and the evaluation with experts.

Flexible project management tool

Facing a complex project? Gain insight into the boundaries of the project and the perspective of the team (include client). Choose the operationalised flexibility enablers to increase flexibility to (better) cope with the project complexity.

-> For more information about the use of the tool, see page 3.



Own illustration based on Jalali Sohi (2018)

1. Insight: Assess complexity elements

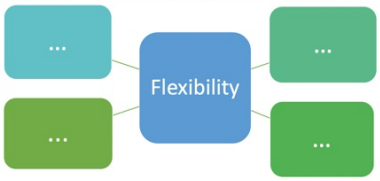
Which elements contribute to the complexity of your project?

- ☐ Dependencies between tasks
- ☐ Involvement different technical disciplines
- ☐ High project schedule drive
- ☐ Interfaces between different disciplines

2. Importance: Create awareness of perspectives within project team

How does the entire project team think about flexibility in managing complex projects?

- ☐ Co-create a word web to discover the perception of the team on flexibility in managing project complexity



3. Implementation: Select flexibility enablers

A. Which flexibility enablers are relevant for the project?

- ☐ Open information exchange among different groups
- ☐ Trust among involved parties
- ☐ Visualised project planning and progress
- ☐ Continuous learning

B. Select the operationalised flexibility enablers that match the selected flexibility enablers, you can find them on the next page. Operationalise these enablers in your project.

4. Improvement: Check what is improved!

Check what is improved after each important milestone. Evaluate the complexities that arise in a new phase and redo the process to keep optimizing.

- ☐ Plan a 'moment to reflect' in the planning

1/3

3B - Operationalised flexibility enablers

Open information exchange among different groups

- ☐ One 'project site' with the project team (relevant with multiple parties in project team)
- ☐ Integrated system with the project team (relevant with multiple parties in project team)
- ☐ Establish a common project culture
  - ☐ Rules on how to interact
  - ☐ Rules on how to deliver things to each other (as parties in project team)
  - ☐ Create the security to be vulnerable
- ☐ Weekly meetings:
  - ☐ Planning board sessions with the project team (short lines of communication)
  - ☐ Standups within the organisation
- ☐ Conversations with client regularly

Trust among involved parties

- ☐ Make sure you have confidence in the project yourself (contract/planning/agreements)
- ☐ Change the agreements of the contract when this blocks trust
- ☐ Prevent people from key positions to leave (by selecting team members that can commit)
- ☐ Kick-off with an informal and formal part, preferably on the location of project
  - ☐ Informal gathering, to get to know the team
  - ☐ Formal part to discuss cooperation rules and expectations
- ☐ Work on one location with the project team
- ☐ Plan regular meetings and sessions together (evaluation sessions etc.)
- ☐ Hire a cooperation coach for the project team
- ☐ Be honest and report when things do not work (and propose a solution)
- ☐ Ask open questions to the team about the progress of work and their personal life

Visualised project planning and progress

- ☐ Get the right people on the team to visualise and structure based on experience:
  - ☐ Planning (to achieve the right level of abtractness in the planning)
  - ☐ Process
- ☐ Facilitate a LEAN planning on the wall
- ☐ Daily stand to discuss the progress (at LEAN planning)
- ☐ Make the work visible (by showing progress/design on screen or printing every week)
- ☐ Sticker sessions (to visualise and align what needs to be done)
- ☐ Common thread sessions
- ☐ Use visualised communication (i.e. by using a powerpoint presentation with visualisations)
- ☐ Visualise relations (in a web or (system) breakdown structures)

Continuous learning

- ☐ Learning trajectory in which experienced involve inexperienced
- ☐ Balance experience in the project team (enough experienced people)
- ☐ Know who you need in the team (based on knowledge, via via and get to know people)
- ☐ Evaluate (between phases, between milestones, in each meeting)
- ☐ Reflections on the executed work

☐ Others... (select project specific enablers from appendix H)

2/3

Tool explanation- step by step

Introduction

When a project team starts with a project, usually a plan is developed for managing the project. In this phase, it is advised to start using this tool. For project teams at Arcadis, this means that in 'The Arcadis Way' this tool should be incorporated in the process 'Deliver to Result' in the step 'Plan project'. This can be incoporated in the Project Management Plan (PMP). This tool has been scientifically created and the limitations of the scope should be taken into account.

Use: The tool has been developed to use for the management roles in the project.

Goal: Create awareness of the complexities and opportunities to incorporate flexibility in the management of the project. (This tool is also intended to start a conversation with the client)

1. Insight: Assess complexity elements

By detecting complexity elemens, insight can be gained into the project complexity. It is important to be aware which complexitity elements contribute to the project complexity to deal with this properly. This is a selection, when other complexity elements are relevant, discuss this and check whether the flexibility enablers could be applied.

Duration: 2 min
Goal: Select the elements that contribute to the project complexity
Who: Project manager(s)
How: Based on own experience and/or consultation of the project team

2. Importance: Create awareness of perspectives within project team

To understand how flexibility is perceived, a word web can be composed with the team. It is important to pay attention to what the team finds important, to select the right flexibility enablers in the next step. When the team is not aware of certain flexibility possibilities, support can be achieved be explaining the chosen flexibility enablers. Include the client!

Duration: 15 min
Goal: Create a flexibility word web that visualises what the team thinks of flexibility
Who: Project manager(s) with the project team
How: Plan a session (e.g. during kick-off) and create a word web (PowerPoint/Mentimeter/...)

3. Implementation: Select flexibility enablers

To use suitable flexibility enablers suitable, it is important to select them based on the two previous steps. Choose the enablers to be operationalised to increase flexibility in the project.

Duration: 20-30 min
Goal: Select the flexibility enablers in step A. Operationalise these enablers in B.
Who: Project manager(s)
How: Determine the enablers that have the potential to contribute to flexibility in the project (incorporate them into the PMP)

4. Improvement: Check what is improved!

To learn from each step in the process, it is important to check what has improved after applying flexibility enablers. Additionally, it can be good to do intermediate checks whether the chosen flexibility enablers are the right enablers and whether they help enough in coping with the selected complexities.

Who: Project manager(s)
How: Plan the moments of reflection in the project planning (after a significant project change, a milestone or a new phase)

3/3

7.4 Conclusion

The tool facilitates more flexible project management by guiding the user in the process of coping with project complexity. In addition, in the expert session, the tool is evaluated and after that improved to answer the fourth sub-question:

| SQ 4: How can project management become more flexible?

To allow for project management to become more flexible, a tool is developed. The tool can be integrated with existing project management to improve management practices for coping with complexities. The improvements can be made by applying the suggested flexibility enablers and continuously improving with the use of the tool.

A draft is composed based on the results of the cross-case and the flexible project management framework of Jalali Sohi (2018) to make flexible project management more accessible for all project managers. A tool of two pages is developed to create a manageable tool that is attractive to use. One page of explanation is added to explain the steps when needed. The tool helps to provide insights into the selected complexities, create awareness on flexibility perspectives from the project team, select the operationalised flexibility enablers, and reflect on the changes made to keep improving.

The tool is evaluated with five experts to validate the tool and make improvements when necessary. The experts were optimistic about the attention to the topic and the awareness created for more flexible management. In addition, the experts experienced the tool itself as useful for incorporating flexibility into project management. The operationalised flexibility enablers were mentioned as the value of the tool. The tool is optimised within the scope of this research and based on the careful considerations of the experts and the researcher.

To conclude, the tool allows project management to become more flexible when dealing with the discussed project complexity. The tool creates awareness for flexibility in projects, helps with the approach for including flexibility and gives options to apply flexibility in the project.

8 Discussion

The validity of the research is discussed in this chapter. First, the discussion points are presented. Second, internal and external validity are discussed. Third, the limitations of the literature are described. Lastly, the practical implications are given.

8.1 Discussion points

Theory from literature is often case bounded by the research context and not universally applicable. This is partly because literature reflects possibilities, and practice is a set of variables coming together, which could become complex in infinite possible ways. Relevant subjects are discussed next.

Flexibility enablers perceived differently in practice

Significant to this research was a result of the cross-cases that showed that project managers do not agree on all flexibility enablers as defined by Jalali Sohi (2018). From the 11 selected flexibility enablers (category how), three were explained differently by the interviewees of the cases. The enablers explained to be different in practice were 'Self-steering of the complete project team', 'shared interface management' and 'network structure rather than hierarchical structure'. Jalali Sohi describes these three enablers to be completely flexible themselves. However, the interviewees needed some structure to let the flexibility enablers fit project management and allow for more flexibility. This suggests that to allow for maximum flexibility in projects, some structure can be required for the application of flexibility enablers.

Difference between a flexible project and a traditional project

To start, there is an inconvenience for the terms 'project' and 'flexibility'. The classical view on project management is focused on controlling the project and is thus not flexible. Flexibility is somehow contradictory to controlling. This makes it challenging to implement flexibility in project management.

Subsequently, the difference between a flexible project and a traditional project (controlling) cannot be expressed in one blueprint since it is dependent on many variables of a project. From the cases, it became evident that the tender and agreements play a significant role in how a project can be flexible. For a traditional project, it would be desired to capture everything in contracts, and this is also still the old fashion mindset that prevails. In practice, it shows that projects could be executed more flexible, but clients rarely write tenders for projects with some flexibility, as this gives them too much uncertainty. Due to the fixation at the front, the project has limited possibilities to include flexibility. However, this boundary can be discussed and might be changed if needed. Whether these changes are perceived as an option depends on the characteristics of the project members: experience, personality and competencies. In one case, the contract form was changed, which impacted the possibilities in the project. The possibilities increased, and more flexibility was applied after the contract change. In the cases, it is explained that trust, conversation and being open and honest is the key for making this kind of changes possible.

Next, applying flexibility depends on the people on the team (knowledge, preferences and experience) and the decisions made on how the assignment (project) will be handled. Flexibility can result in major advantages and should be explored further to gain insights into its gains and pains. Therefore, the more traditional mindset on projects should shift to a more flexible mindset.

Experience is key

The literature review shows that various 'right' variables can, in theory, make a successful project. For example, applying the flexibility enablers of Jalali Sohi (2018) should help manage complexity and result in a more successful project. This appears to be more nuanced in practice since finding all the correct variables for complex projects is impossible. There is not one 'right' way to cope with complexity and respond properly to emerging complexity. Gut feeling and experience seems indispensable. With experience, the situations must be assessed and the strategy determined to manage them best possible. Experience is the key, and attention must be paid to training and deploying the right people.

8.2 Internal & external validity and reliability

Internal validity is about using proper research methods the right way, leading to robust conclusions (McDermott, 2011). In general, the research has been set up systematically, and experts have evaluated the results. The external validity is the degree to which the conclusions of the research can be generalized. First, the internal validity is discussed and next, the external validity.

The use of triangulation makes the internal validity of this research considerably high (Eisenhardt, 1989). Different methods (document analysis, interviews, expert session) applied with multiple inputs (various documents, more than one interview) contribute to the results, which leads to a supported conclusion within the scope of this research.

Given the amount of research in this area, a large table of terms with different combinations possible was created. Through scanning the found literature, proper judgement on the relevance of the topics could have been made. A selection of literature has been made to apply focus in the research. The selection of literature is established based on applicability for this research and personal knowledge of the subjects. First, a selection of applied methods has been made based on selected literature, followed by a selection of complexity and flexibility elements (of the methods) that limited the research. Different studies have been done on the used methods, complexity elements and flexibility elements. For broader applicability, i.e., outside the domain of infrastructure, other literature has to be taken into account as well.

The company at which the case studies have been conducted is a well-known engineering company experienced in the field of complex infrastructure projects. The interviewees were chosen based on experience to increase the reliability of the data and the internal validity. However, the group of interviewees might not have been diverse enough. An estimation was made on the management approaches of the project managers. These approaches were estimated for two cases, more to the controlling side and two cases more to the flexible side. It turned out that the project management approach was close to average in three of the four cases. The method used for scoring and judging the project management approach could be questioned since the interviewees rated the approach themselves and a method was used that is not widely tested. However, the project management approaches scored by the two interviewees of one case often aligned, or the difference was due to a different perspective of the interviewees.

For the case study, also a structured way of working was applied. This method enabled us to interpret the information and compare the results. Conducting document analysis and two interviews per case increases the internal validity since perspectives could be compared. Prior to the interviews, two forms were sent to the interviewees to gather relevant prior knowledge to deepen the subject. It is possible that sending information before the interview affected the interviewees and resulted in biased answers. However, when conducting the interviews, it was perceived positively to be able to ask more specific questions about the received forms. The methods used in this research are single methods that are combined. It could be questioned whether these methods are the best combination or whether single methods should be combined in such a way. However, in research, a step-by-step process combining different aspects (methods are implicated) is desirable and helps find the different aspects of complex projects to manage them better.

The validity of the tool is high within the context of this research. The experts valued the tool positive, and in the expert session, valuable feedback was provided and incorporated into the final tool. The next step for the tool is validation in practice, using the tool in a project setting. Real-life tests from the start of new projects with project managers are recommended. As real-life tests were out of scope, a presentation was given on the research, the results and the draft of the tool. This allowed the experts to judge the tool on usability but could also have influenced the experts. Since a discussion on every subject was held and substantive comments were provided, this content bias was minimalised.

Overall, all participants were primarily positive about flexibility, which is remarkable. It was expected that participants would have been more critical on applying flexibility in practice since the view on project management is often based on the traditional view. However, in the cases, the interviewees searched for flexibility when executing the assignments because clients often limit possibilities. The client's perspective should be considered as it could differ from the perspective of the project manager.

This research was aimed at making available literature on flexibility enablers better applicable in practice. The research is directed to the case studies and expert sessions within Arcadis that allowed for a glimpse from practice in the construction sector. The external validity is limited since this exploratory research only focuses on a subsection of the entire construction sector. In addition, the number of cases and interviewees is based on four projects, therefore the result of a single project highly influences the outcomes. This fits the

qualitative nature of the study but limits the broader applicability of the research. Therefore, the tool should be validated in more cases and broader contexts (such as other organisations in the sector) to be broader applicable. The number of cases and interviewees should be considered in the conclusion of the cases. However, the qualitative research was conducted using a diverse set of four case studies to increase the validity of differences in (construction) projects.

The reliability of this research is taken into account by making the research replicable due to its structured setup and careful execution of the study. From literature, different steps are retrieved to deal with complexity properly. These steps are considered into the method execution and the processing of the results. The strategy and methods are described and executed carefully and consistently. The used documents, forms and interview setups for this study can be found in the appendices.

8.3 Implications

This research explored the possibilities to manage complex projects in a flexible manner. Thereby the knowledge is broadened of how flexibility enablers could be used in complex project management. Previous research often focuses on controlling complexity or suggesting how to cope with complexity by suggesting flexibility theories or new methods. This research shows how flexibility can be included in practice independent of the management method. This provides more structure to allow flexibility in different management methods.

Through the case studies, complexity elements and flexibility elements relevant for complex infrastructure projects are distinguished. With those elements, a tool is established to improve project management in terms of flexibility and dealing with complexity. These findings and results can be used in future research and contribute to the literature on these subjects.

Practical implications

1. More attention must be paid to flexibility in project management, also in other roles than of the project manager, to be able to respond to the emerging complexity. A flexible mindset of everybody involved in the project is desired to be able to apply more flexibility as a team.
2. Experience is key, and attention must be paid to training and deploying (the right) people. Experience makes people more flexible because they know how to cope with different situations and better cope with project complexity.
3. Clients must change their attitude and procedures towards projects. Flexibility is required to respond appropriately to all situations in projects for the client and the project team.
4. It is found that asking an open question for a tender establishes room for flexibility and that a complete set of requirements can limit flexibility. Public clients, who often tender infrastructure projects, should explore if they can set up a tender with an open question despite regulations and procedures.
5. The conversation needs to be initiated with the involved parties to make a more flexible project management approach common (with the client and other parties in the project team).
6. The discussion should be initiated to allow more flexibility when the contracts limit a project in dealing with complexity.
7. Include a collaborative risk pot (shared with contractor and client) for each complex project to allow for proper responses to emerging complexity and stimulate collaboration and trust between the parties, allowing for more flexibility in the project.

9 Conclusion

The conclusion of the research is presented in this chapter. First, the sub-questions have been answered to lead to the conclusion of the main question. The chapter ends with recommendations for practice and future research.

9.1 Conclusion

This study aims to (1) develop a theoretical background for possible challenges in complex project management, (2) illustrate the current use of flexibility in management, (3) find the possibilities for incorporating flexibility in project management and (4) develop and validate a strategy for coping with project complexities. Four sub-questions have been addressed to achieve these objectives. The answers to the sub-questions have been summarised, after which the research question is answered:

| RQ: How can flexibility enablers facilitate the management of project complexity?

The first sub-question is **'What are the challenges in the management of complex infrastructure projects?'**. This question is answered through literature by analysing relevant challenges that must be overcome to cope with project complexity, focusing on the use of flexibility. The first challenge is to grasp complexity. The TOE framework is chosen to dive into relevant complexities related to the construction sector (see Table 15, except 1, 9 and 10). When the complexities are mapped, the management approach must be adapted accordingly. Adapting the project management to the project complexity is the second challenge. Flexibility must be embedded into project management. Eleven flexibility enablers have a proven relationship with project complexity and are taken into this research to explore operationality further (see Table 16). In combination with the complexity elements, these enablers have been further examined in a case study to determine how they can be applied in practice.

Table 15 Selected complexity elements

		Complexity elements
1	Technical complexity	Non-alignment of project goals*
2		Uncertainties in scope
3		Project duration
4		Dependencies between tasks
5		Involvement of different technical disciplines
6	Organisational complexity	High project schedule drive
7		Lack of resource and skills availability
8		Interfaces between different disciplines
9		Size of project team*
10		Lack of trust in project team*
11	External complexity	Remoteness of location
12		Interference with existing site
13		Political influence
14		Variety of external stakeholders' perspectives
15		Number of external stakeholders

Table 16 Selected flexibility enablers

	Flexibility enablers
1	Self-steering of the complete project team
2	Open information exchange among different groups
3	Shared interface management
4	Contingency planning
5	Seizing opportunities and coping with threats
6	Trust among involved parties
7	Standardise the process and design
8	Visualised project planning and progress
9	Possible alternatives
10	Network structure rather than hierarchical structure
11	Continuous learning

* In Table 15, the 12 complexity elements from literature have been complemented with three elements that were also emphasised in conversations with experts prior to the case studies. The three complementing elements are 'Non-alignment of project goals', 'Size of project team' and 'Lack of trust in project team'.

The second sub-question, "**How is flexibility currently incorporated in the management of project complexity?**" aims to discover how flexibility is used in project management to deal with complexity. Therefore the 15 complexity elements and the 11 flexibility enablers were used to assess the case study on complexity and flexibility. In addition, a framework for the project management approach was used to obtain insight into the current project management approach. Via established forms and semi-structured interviews,

information was retrieved on complexity, project management approach and flexibility. The interviews combined with the forms resulted in a long list of the operationalised flexibility enablers from the cases. It was found that the applied flexibility mainly was related to communication, interfaces and planning. From the cases, it has been concluded that project managers often see the need for flexibility to be taken into project management.

The goal of the third sub-question, "**What are the opportunities for incorporating flexibility in the management of project complexity?**" is to identify the opportunities for flexibility in project management by conducting a cross-case study. First, it is found that four complexity elements are most relevant for contributing to the project complexity of the cases. These complexity elements are (1) 'dependencies between tasks', (2) 'involvement different technical disciplines', (3) 'interfaces between different disciplines' and (4) 'high project schedule drive'.

Subsequently, seven flexibility enablers were indicated to be important for dealing with the complexity elements. The three enablers (1) 'self-steering of the complete project team', (2) 'shared interface management' and (3) 'network structure rather than hierarchical structure' were not supported for their content by the interviewees. These flexibility enablers were explained differently, namely with more structure, allowing for flexibility and being applicable in project management practices.

The other four enablers that have been perceived as necessary and applicable in project management are (4) 'open information exchange among different groups', (5) 'trust among involved parties', (6) 'visualised project planning and progress' and (7) 'continuous learning'. These elements are related to coping with project complexity in management and are operationalised in the cases. Therefore, these operationalised flexibility enablers have been listed so project managers have an overview and can apply 'new' or other flexibility enablers to better cope with project complexity in the future.

No explicit one-to-one relations were distinguished between elements of complexity and flexibility. However, some relations were found between multiple complexity elements and flexibility enablers. The complexity elements 'dependencies between tasks', 'involvement different technical disciplines', 'interfaces between different disciplines' were indicated to have a positive relationship with the flexibility enablers 'open information exchange among different groups', 'trust among involved parties', 'visualised project planning and progress'. The element 'continuous learning' is explained to affect many of the complexity elements positively and can be helpful to support controlling different types of complexity. This emphasizes the need for the flexibility enabler 'continuous learning'. When the discussed complexity elements contribute to the project complexity of infrastructure projects, the selected flexibility enablers can be selected and applied to cope more flexibly with the project complexity.

The last sub-question, "**How can complex projects become more flexible by applying flexibility enablers?**" has clarified how flexibility could be included in project management. Based on the selection of complexity elements and flexibility enablers, a flexible project management tool is developed, evaluated and finalised. The tool consists of four steps. The first step is to select the relevant complexities for the project to become aware of the complexities in the project. The next step is to create awareness of the perspectives on flexibility in the whole project team to know the team and their perspectives/opinions a little better. This helps to select the appropriate flexibility enablers in the next step. In this step, the flexibility enablers that need to be improved in the project are selected first. Next, the operationalised flexibility enablers must be selected and applied in project management. For instance, these elements can be included in a project management plan to ensure they get included in the project. The final step is a 'check' to learn from the process and check what has been improved after applying flexibility enablers. It is an iterative process that can be done repetitively to keep making project management more flexible. The iterative process must be included in the project, not to be pushed aside when the pressure increases. The tool can facilitate more flexibility that allows for the pressure not to overrule.

The tool helps with the approach of how to select flexibility enablers and offers a range of operationalised flexibility enablers to choose from. This allows for flexibility to be included and integrated into existing project management practices to improve coping with complexities. Since it is not a static event of including flexibility enablers, it must become a dynamic and iterative process of improving and integrating more flexibility in project management throughout complex projects.

Together the answers to the sub-questions build towards the main conclusion and answer the research question:

| RQ: How can flexibility enablers facilitate the management of project complexity?

This research illustrated how flexibility could help to cope with project complexity. This helps to prevent the negative consequences of project complexity. A selection has been made for relevant elements of complexity and flexibility enablers to be studied in practice based on the literature. The case study and expert session showed how the selected elements could be explained and used, and relations have been found between the selected elements. It is concluded that the perception of flexibility differs from the application of flexibility in practice. Awareness and inspiration for operationalising flexibility could help to improve the application of flexibility. Therefore, a list of operationalised flexibility enablers is composed to become aware of possibilities and support implementation.

Different complexity elements were found to be relevant when dealing with project complexity, particularly interface management. This study illustrated that managing more flexible can help to cope with the complexity. It is found that an open question for a tender establishes room for flexibility and that a complete set of requirements can limit flexibility. Subsequently, the circle of influence of the project manager and the team determines whether flexibility can be applied to cope with project complexity. The experience, personality and competencies of a project manager influence the possibilities and attitude towards complexity and flexibility and how it is dealt with.

The awareness for flexibility in project management is essential at the side of the client and contractor. Both parties need to be aware of the subject and the possibilities to better cope with project complexity. Even the awareness can already help for more flexibility in the project. Awareness boosts the application of flexibility enablers such as trust and open communication

Various flexibility enablers were operationalised in the cases for coping with project complexity. Four of those flexibility enablers were emphasised to be essential and operationalised in the cases: 'open information exchange among different groups', 'trust among involved parties', 'visualised project planning and progress' and 'continuous learning'. In addition, these flexibility elements were linked to project complexity in several ways, indicating the effect they have on coping with multiple complexities. These enablers reflect the importance of soft factors such as trust, communication, transparency, teamwork, and experience in projects to execute them adequately. The operationalised enablers make these soft factors applicable.

The flexible project management tool was developed for applying the four flexibility enablers to cope with project complexities. The tool is meant for project managers of a complex infrastructure project and their teams. The tool helps to provide insights into the selected complexities, create awareness on flexibility perspectives from the project team, select the operationalised flexibility enablers, and reflect on the changes made to keep improving. The tool is also helpful for conversation with the client since that stimulates flexibility and creates awareness.

9.2 Recommendations

Based on this research, the following recommendations are proposed for practice and future research.

Practical recommendations

Six practical recommendations are proposed for the project managers of Arcadis and others involved in projects. In addition, it is advised for project manages of infrastructure projects to be aware of these points.

1. Awareness must be created for flexibility in project management within Arcadis. This could be done by including the flexible project management tool in The Arcadis Way, where project managers can choose to include the tool in their project management approach. In addition, it could be interesting to take this to a higher level in the organisation through coaching leadership and training for employees to encourage flexibility in project management.
2. To take in flexibility in the management of project complexity, it is advised to apply the developed tool. To allow project managers to find the tool, it is necessary to place it in the online environment in a logical place. The tool could even be developed into modules to make the tool more accessible.

3. The flexibility enabler that refers to trust forms a basis for coping with complexity. It is essential to put time and effort into this enabler to establish trust in the project team. Especially for the relation with the client, trust is necessary to invest in. This often lacked in the cases and was emphasised to improve.
4. Open data platforms or project sites for projects and/or Arcadis (organisations) are recommended. This makes it easier to find all the information on projects during a project and after projects are finished. This could help when information is required in situations that are not familiar with but did happen before.
5. When the contract limits the possibility of coping with complexity and thereby applying flexibility, the subject must be brought to the table to make it negotiable whether contract changes would be in place.
6. A difference was found in perspective on the element 'self-steering of the complete project team'. In three of the four cases a difference in perspective between the project managers and the other roles from interviewees. Project managers were semi-positive, and the others were negative. The project manager and team must be aware of the preferences and make agreements on what would work for the extent of self-steering in a project.

Recommendations for future research

Six recommendations for future research are presented.

1. The experience of project members and managers appeared to be an essential aspect of employing flexibility. However, by conducting this research, it could not be explained how the experience relates to the management of complex projects. This relation could be studied more explicitly. Competences and personality also play a role in experience and project management, and these aspects could also be considered. The following question is suggested to study this proposal: "How does the experience of project members relate to the flexibility possibilities in a complex infrastructure project?". This question could only focus on the experience of the project manager to apply focus in the research.
2. This study demonstrated that clients play a role in the possibilities for the inclusion of flexibility in project management. It should be studied how clients (public and private) could allow for flexibility in projects to facilitate more opportunities. The allowance for flexibility starts with the client's mindset, allowing flexibility to cope with complexity and includes aspects such as the tender, the contract (form). Related to this topic, a suggestion for a research question could be: "How can clients facilitate the implementation of flexibility to cope with complex infrastructure projects?". Qualitative research is advised, for which a case study could be used.
3. Opposite and in addition to the previous suggestion, it is interesting to look at how contractors can win tenders, allowing flexibility to facilitate a manageable complex project. Can contractors apply for tenders while creating more flexibility in an early stage to allow for more flexibility through the entire process? The goal is to study the current project environment and how to adapt to get the most out of it at an early stage. A qualitative study could be applied to discover in-depth data on possibilities.
4. This research could be conducted at other contractor organisations with different characteristics to compare perspectives and find the relations of flexibility between different contractors. The same research question could be used 'How can flexibility enablers facilitate the management of complex projects?'. When this research is reproduced to compare, a similar method is advised.
5. How do flexibility enablers go together with different contracts; can they always be applied, or should a particular flexibility enabler already be included in the contract to make more flexibility possible? The proposed research question is: "How do flexibility enablers relate to contracts in project management to cope with project complexity?". To find in-depth information, a qualitative study is advised. Different methods could be appropriate (i.e., case study, interviews, observations, surveys).
6. In this research, the flexible project management tool is established based on four cases from one company. It would be interesting to test (and expand) the tool in other project organisations. A research question could be: "How could the flexible project management tool be embedded in construction organisations to allow for more flexible project management?". Doing a qualitative study would be appropriate for this 'how' question. To expand the tool, another question could be relevant: "How could the flexible project management tool be expanded to allow for project management to become more flexible?". It could be interesting to study all the complexity elements of the TOE framework and the flexibility enablers to explore more relations and develop more possibilities (and perhaps be more specific on when to use the operationalised flexibility enablers).

Reflection

During my masters, I have looked forward to the moment of starting and doing my graduation thesis. Some setbacks were encountered during my masters, which postponed the moment of graduating for me. However, I look back at a valuable time because I did not only learn plenty during studying, I also got to know myself better and learned how to persevere when things go different from planned. Construction Management and Engineering (CME) is a master that suits me, and I was excited to start working on a subject of my own.

Choosing a subject was one of the trickiest parts of my thesis. I did not know which subject of my selection I had to choose. I have decided to dive into complexity and flexibility because this is a subject that intrigues me. This turned out to be a good choice because every time someone asked me about my graduation thesis, I could genuinely say that I enjoyed working on my thesis. Maybe it overexcited me because, during the case studies, I had a hard time focusing. I would have loved to study all the collected information and deliver a total package of findings, unfortunately, this was not possible within the scope and timeframe of my research. My committee told me to focus, and I am happy that they did. Otherwise, I would still be working on the case study, and I would have lost the thread of my thesis.

Complexity and flexibility are topics that speak to me because I find them in everything, and it keeps me thinking. One uniform solution for coping with complex infrastructure projects is impossible, but people need some guidance or examples to take the challenge and be confident. I was determined to take a step in the direction of facilitating that guidance to take on those challenges more easily. Throughout this process, professionals recognised the need for managing complexity by employing more flexibility which made this a delightful process to continue, with valuable collaborations.

During my thesis, I was thinking about what the deliverable could be like. What form should it get when complexities should be discovered, and flexibility should oppose as a reaction? When I was able to let these thoughts go, and when I accepted there would be no one-to-one link between the two aspects, it came to me, and I was able to create a tool where everything fell into place within the scope of my research. The structure I used to work through the case studies could be reflected in my tool, and it was right.

When I look back on the months of performing my thesis, I can say that I am very proud of the research that I have conducted.

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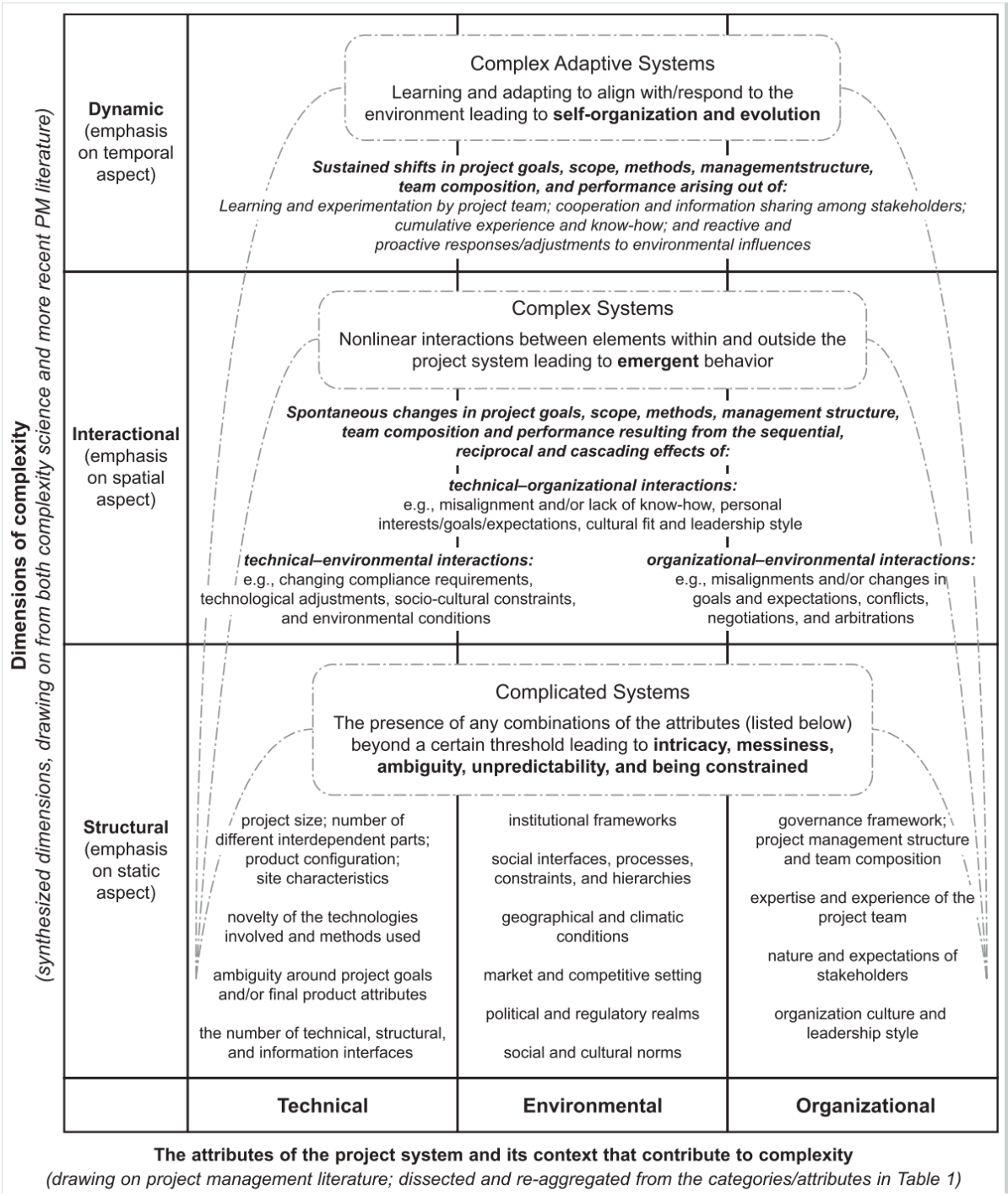
Appendices

A. Complexity Assessment Tool (CAT) by (H. R. Maylor et al., 2013)

The Complexity Assessment Tool

	Areas of complexity • Structural Complexity (1–21) • Sociopolitical Complexity (22–32) • Emergent Complexity (defined by expectations for stability)	Do you agree with this statement? (Y/N)	Do you expect this situation to remain stable (i.e., NOT to change)? (Y/N)
Structural Complexity			
1	The vision and benefits for the work can be clearly articulated.		
2	Success measures for the work can be defined in agreement with the client.		
3	The technology is familiar to us.		
4	The commercial arrangements are familiar to us.		
5	The scope can be well defined.		
6	Acceptance criteria for quality and regulatory requirements can be well defined.		
7	A schedule and resource plan can be well defined.		
8	The supply chain is in place.		
9	Lines of responsibility for tasks and deliverables can be defined.		
10	Accurate, timely, and comprehensive data reporting is possible.		
11	Existing management tools can support the work.		
12	Sufficient people with the right skills are available.		
13	Managers have adequate control of human resources (i.e., direct reporting).		
14	Key people are wholly allocated to the work.		
15	Integration across multiple technical disciplines is not required.		
16	The budget is sufficient for the task.		
17	The budget can be used flexibly.		
18	The work will be carried out in a single country/time zone/language/currency.		
19	The work is independent of other projects and business-as-usual operations.		
20	The pace is achievable.		
21	Resources (e.g., test facilities, equipment) will be available when needed.		
Sociopolitical Complexity			
22	The work has clear sponsorship consistent with its importance.		
23	The business case for the work is clear.		
24	The goals for the work align with the organization's strategy.		
25	Your own senior management supports the work.		
26	Team members are motivated and function well as a team.		
27	Managers are experienced in this kind of work.		
28	The work involves no significant organizational/cultural change.		
29	The work will be unaffected by significant organizational/cultural change.		
30	The external stakeholders (i.e., not immediate team members) are aligned, supportive, and committed to the project and have sufficient time for the work.		
31	The external stakeholders (i.e., not immediate team members) have a realistic, shared understanding of the implications of the work.		
32	The core team has the authority to make decisions.		

B. Dimensions of complexity by (Kiridena & Sense, 2016)



The attributes of the project system and its context that contribute to complexity

(drawing on project management literature; dissected and re-aggregated from the categories/attributes in Table 1)

C. Semi-structured Interview Guide (EN&NL)

EN - Semi-structured interview guide

Name: …… M/F Age: …… Project: ……..
Function: …… Experience PM: …… Project duration: ……..

Interview set up: 5 min

- Description research
- Goal interview
- Main themes questions
- Permission to record

- Making flexibility web together [screen sharing ppt] 5 min

Personal questions *5 min*

1. What is your job description?
2. What is complexity to you?

Project questions *20 min*

3. What kind of complexities did you encounter that affected the project?
   - When are complexities encountered?
   - What was the impact of the complexity?
   - → Show TOE-framework selection and relate [Present/show in ppt]
4. How are the complexities dealt with?
   - When you could do it again, what would you do differently?
5. How did you apply flexibility in managing the project complexity?
   - When?
   - Why?
6. Looking back, were there other moments that flexibility should have been included?
   - When?
   - Why?

Flexibility enablers [present/show in ppt] *25 min*

7. What flexibility enablers could have been relevant in the project?
8. How could those flexible enablers have been applied?
9. Do you have concerns for implementing flexibility?
10. Are there other aspects that you think are important?

NL - Vragenlijst semigestructureerd interview

Naam: …….. M/V Leeftijd: …… Project: ……..
Functie: …… Ervaring PM: …… jaar Project duur: ……..

Opzet interview: 5 min

- Beschrijving onderzoek
- Doel interview
- Thema's vragen interview
- Toestemming vragen om op te nemen

- Flexibiliteit web maken (samen) 5 min

Persoonlijke vragen *5 min*

1. Wat is jouw functieomschrijving?
2. Wat is (project) complexiteit voor jou?

Project specifieke vragen *20 min*

3. Welke complexiteiten ben je tegengekomen die het project hebben beïnvloed?
   - Wanneer stuitte je op de genoemde complexiteiten?
   - Wat was de impact van de complexiteiten?
   - [Laat TOE (elementen) zien en relateer]
4. Hoe is er omgegaan met de complexiteiten?
   - Wanneer je het over zou kunnen doen, wat zou je dan anders doen?
5. Hoe heb je flexibiliteit toegepast in het omgaan met/managen van de project complexiteiten?
   - Wanneer?
   - Waarom?
6. Terugkijkend op het project, waren er andere momenten dat het inzetten van flexibiliteit waardevol was geweest in het managen van project (complexiteit)?
   - Wanneer?
   - Waarom?

Flexibility enablers [presenteer de flexibility enablers, uitleggen 3 categorien-> how] *25 min*

7. Welke flexibility enablers hadden relevant kunnen zijn in het managen van het project?
8. Hoe hadden deze flexibility enablers toegepast kunnen worden in het managen van het project? Hoe operationaliseer je deze flexibility enablers?
9. Wat zijn uw zorgen omtrent het verwezenlijken van flexibiliteit in het management van een project?
10. Welke andere aspecten acht u belangrijk?

Project complexity assessment form

Name:

Project:

Thank you for taking the time to contribute to my research and filling in this form!

Instructions PDF (form)

This form is created as an interactive PDF. Please fill in your name and and the name of the project. Afterwards, you can rate all the aspects for contributing to the project's complexity by clicking on the circle of choice. Each aspect should be rated.

Explanation of the assessment

The idea of this form is to express the contribution to the complexity of the project, per subject, based on a scale from zero to four (none to much). The choices are none (0), little (1), some (2), substantial (3) and much (4). None means that the specific complexity does not play a role and much means that the aspect contributes a lot for the complexity of the project. As an expert you may judge this complexity scale based on your experience.

For questions please contact:

[illegible]

Notes / Suggestions:

T Technical Complexity	CONTRIBUTION TO PROJECT'S COMPLEXITY None (0)	Little (1)	Some (2)	Subst. (3)	Much (4)
1. Non-alignment of project goals Only if more than one strategic goal is present: amount of non-alignment (completely aligned – completely unaligned)	◉	◉	◉	◉	◉
2. Uncertainties in scope Presence of uncertainties in agreed scope of work (no uncertainties – lots of uncertainties)	◉	◉	◉	◉	◉
3. Project duration How long is the planned duration, compared to your reference (short – very long)	◉	◉	◉	◉	◉
4. Dependencies between tasks What is the number and nature of dependencies between the different tasks? (small – many & pooled)	◉	◉	◉	◉	◉
5. Involvement different technical disciplines What is the level of multi-disciplinarity? (single – very multidisciplinary)	◉	◉	◉	◉	◉
O Organizational Complexity	**None (0)**	**Little (1)**	**Some (2)**	**Subst. (3)**	**Much (4)**
6. High project schedule drive How high was the pressure on the project schedule? (not at all – should be finished yesterday)	◉	◉	◉	◉	◉
7. Lack of Resource & Skills availability Are there any problems in the availability of the resources (materials, personnel) and skills required for the project (all available – major problems in availability)	◉	◉	◉	◉	◉
8. Interfaces between different disciplines Are there many interfaces between the different disciplines involved (like mechanical, electrical, civil, finance, legal, communication, etc) that could lead to interface problems? (few interfaces – many interfaces)	◉	◉	◉	◉	◉
9. Size of project team How many persons are within the project team (few (1-5)- many (>200))	◉	◉	◉	◉	◉
10. Lack of trust in project team Do you trust the members of the project team (completely – not at all)	◉	◉	◉	◉	◉
E External Complexity	**None (0)**	**Little (1)**	**Some (2)**	**Subst. (3)**	**Much (4)**
11. Remoteness of location How remote is the project location located, think of reachability, availability of infrastructure and other facilities (easily reachable – very remote)	◉	◉	◉	◉	◉
12. Interference with existing site Do you expect interference between the current site or the current use of the site and the (foreseen) project location?	◉	◉	◉	◉	◉
13. Political influence To what extent does the political situation influence the project (no political influence – severe political influence)	◉	◉	◉	◉	◉
14. Variety of external stakeholders' perspectives To what extent do the perspectives of the different stakeholders differ? (not so much differences – completely different)	◉	◉	◉	◉	◉
15. Number of external stakeholders How many external stakeholders are involved in the project; those parties that can influence or are influenced by the project? (few – many)	◉	◉	◉	◉	◉

2. Project management approach form

Name:

Project:

	Focus on control				Focus on flexibility
	1	2	3	4	5
Terms of reference	Blueprint				Functional
The goal/purpose of the project as defined at the start and during the project.	The goal/purpose of the project is fixed as defined at the start of the project. There is a strong focus on front-end analysis and designed to overcome uncertainty and complexity. The front-end should predict expected outcomes accurately and as such produce a blue-print type scope. Budget and schedule of the project are frozen during the execution phase.	A large part of the goal/purpose of the project is fixed as defined from the start of the project. Some room for discussion of scope extension is possible but avoided. Most uncertainty on the project is prevented by a sufficient level of front-end analysis.	The main objective of the project is fixed, there is however some room for discussion on scope and budget. Some front-end analysis is executed to take away some of the uncertainty. Some level of uncertainty and complexity to the project to a certain extent accepted.	A significant part of the project objective is broad and ambiguous. Some details of the objective are fixed, however there is still room for discussion on scope and budget. Most uncertainty and complexity on the project are accepted.	The final goal for the project is broad and ambiguous and strives to fulfil a function. Scope and budget are still open for discussion and the project starts with only functional requirements. Uncertainty and complexity on the project are accepted.
Task definition	Narrow for best control				Broad for best cooperation
Definition of the tasks for the project based on the goal/purpose	Narrow definition of the tasks to keep control and overview of everything that needs to be done. Tasks are appointed to specific parties and participant, there is a strict role division within the project organisation and participation is discouraged.	The project organisation is strictly structured and task definitions are narrow for best control. There are some exceptions on shared roles or disciplines but participation with other disciplines is mostly discouraged.	The project organisation is structured via a strict task description. Tasks are appointed to specific parties and participant. Some collaboration is however stimulated. Multiple roles participate in decision-making process, even if decision is not fully their described task.	There is some task description of for the available disciplines. Member are however stimulated to fill in multiple roles or at have some level of affection with the other roles. Common knowledge is stimulated every team member feels the importance to participate in most decision-making processes.	Tasks of broadly defined to stimulate collaboration and cooperation between actors on the project. There is an importance and prestige of common knowledge. Roles on the team are shared and every team member feels the importance to participate in every decision-making process.
Contract	Task execution				Functional realization
The aim and purpose of the contracts on the project	The contact stimulates the executions of specific tasks, the contract includes objectifiable requirements. (e.g. Bid-Build, RDW-Bestek)	Fixed price contracts with some incentives of reimbursements. Mostly fixed specifications, fixed dates, target price.	Cost plus, target specifications, target date, the client pays the cost-plus profit margin.	Time or work based contracts. No complete specifications, price based on rate.	The contract focuses on the realization of functions, not specific objects. (e.g. Design team, D&C, Alliance, DBFM)
Incentives	Work task based				System-output based
Incentives for the parties based on the contract	Parties are stimulated to work task based, don't think and work outside the scope of the project. Work in a direct line toward the goal/purpose of the project.	Main focus of het project is the realization of the scope of the project. Parties and participants are stimulated to work directly towards this goal however, some broader approach is accepted.	There is a clear scope towards which the project organisation is working. There is however a strong focus on realizing a project with a high level of appreciation from most of the stakeholders. Participants have faith in the success of the project.	Participant and parties are stimulated to work system based and also think and work outside of the scope. There is some stimulation to work towards the goal of the project. Actors have a positive behaviour towards the success of the project and the achievement of a high level of appreciation from most stakeholders is a focus point.	Incentives for the contract are based on system-output. Next to this, there should be a principle of faith, that is, although the outcome is not sure, actors should have faith in a positive result. The project would not get off the ground if not all actors would have a positive behaviour towards the success of the project. Achievement is to realize a project with a high level of appreciation from most or all stakeholders.
Change	Limit as much as possible				Facilitate as much as possible
Attitude towards change on the project	Changes need to be prevented or avoided. Emphasis on control and limit flexibility of the project. Put a strong focus on the front-end development to predict and avoid uncertainties on the project. Risks on the project are tried to be avoided or constrained	Most changes need to be prevented or avoided. Most focus is on control and the limitation of flexibility on the project. Risks are extensively assessed and tried to be avoided or constrained. Some small changes are applied if the benefit for the project are significant.	Some level of uncertainty is accepted. Changes, rework and iterations are accepted, and actors have the possibility to search for opportunities to improve the project. There is however some emphasis on control and a focus is therefore put on some level of front-end development to avoid certain uncertainties.	The organisation is prepared for changes and ought to be flexible and open for adaptations. Uncertainty and complexity are accepted from the beginning. And some risks can also be seen as opportunities for the project to be exploited. There is however some limitation to the level and amount of changes and level of search for opportunities.	The organisation is prepared for changes on the project, changes need to be facilitated and the organisation ought to be flexible and open for adaptations. Rework and iterations are expected from the start of the project because uncertainty and complexity are accepted from the beginning. Risks are also seen as opportunities for the project and can therefore be exploited or purposely searched for.

Steer	Hierarchical				Network
How is the project organisation structured?	The structure of the project organisation is hierarchical. There is a focus on structure of the organisation and decisions are made at the top of the organisation. Working behaviour is governed by instruction. Superiors keep a holistic view of the project and make the decisions. The principle agent theory is applied.	The project organisation tend to be hierarchical. Most information is kept at the top of the organisation and most work is governed by instruction. There is however some emphasis on information transfer.	The structure of het project organisation is more strategic based. Main focus is on functioning of the organisation, focus on maximizing its performance. Not all actors have the same information available. Tasks are mainly delegated, certain level of autonomy of the manager but demanding maximizing share value. The strategic approach is applied.	The project organisation tend to be more network oriented. Main emphasis is still put on information and advice. Stimulation of instructions rather than decisions. Collaboration is stimulated between all actors. There is however a small level of autonomy within the organisation, not all decision are made by all actors.	The structure of the project organisation is more horizontal or in a network formation. There is a superior function of information and advice rather than instructions and decisions. The emphasis is on the social process, stimulating collaboration and participation of all actors. The stewardship theory is applied
Information exchange	Limited, standardized				Open, unstructured
How is information transferred within the organisation	Information is kept at the top of the organisation and if shared, the information transfer is limited and standardized. Information exchange is based on facts and figures and is only done via formal notifications. Project organisation makes use of standardized forms and ways of communication to formalize information transfer.	Most information is formalized and notified to the top of the organisation. Information transfer is mostly linked to facts and figures. Team members are forced to make use of standardized forms for agreements, notifications or significant changes.	There is a certain level of trust that some of the information is transferred openly within the organisation. However, most information transfer is formalized, and notifications are communicated via a standardized form.	Most of the shared information within the organisation is done informally. Most information is open and unstructured. And there is a significant level of trust that information needed is present within the organisation. Only significant changes in scope or large role overarching issues are formalized.	Information transfer is open and unstructured. Information can be located anywhere within the organisation and is shared through an open and transparent way. Importance and prestige of common knowledge and emphasis on shared learning. Most information and knowledge are shared via informal communication and is often demand driven. There is a certain level of trust that all information needed, for a good project execution, is present within the organisation.
Interface management	Project management task				Shared task
How are the interfaces between the different parties on the project managed?	The project manager of the organisation is in charge of the interface management. The project manager can be seen as expert and is therefore in control. (e.g. principle-agent). All decisions are presented to the project manager and regular reports on progress are submitted.	The project manager is the ultimately responsible for the interface management. He is in control and is regularly informed on progress and decisions. Based on some level of trust, the participants have some responsibilities for small tasks and decisions.	Interface management is mostly a shared task. Participant carry some level of responsibility. There is some level of trust and self-control. There are however regular meetings to discuss progress and decisions with the rest of the organisation.	All actors are in self-control, have some level of responsibility which is all based on a certain level of trust. The project manager facilitates this environment. The project manager is sometimes informed about progress or decisions made on an irregular basis.	Interface management is a shared task for all the actors involved. Responsibility is therefore also transferred over every participant. The project manager in this case, act as facilitator in stat of superior. This collaboration is based on trust and self-control. (e.g. stewardship theory) there are no regular planned meeting to inform on progress or decisions.

Instructions PDF (form)

This form is created as an interactive PDF. Please fill in your name and and the name of the project. Afterwards, you can rate all the subjects on similarity to your management approach in the project by clicking on the circle of choice. Each aspect should be rated. An explanation is given under each subject to clarify what is meant exactly (for the subject and for what it means for te management approach).

For questions please contact:

Explanation of the assessment

The idea of this form is to express approach of the project manager related to the specific project, per subject. The choices are specified per subject.

Notes / Suggestions:

F. Flexibility word webs in Dutch

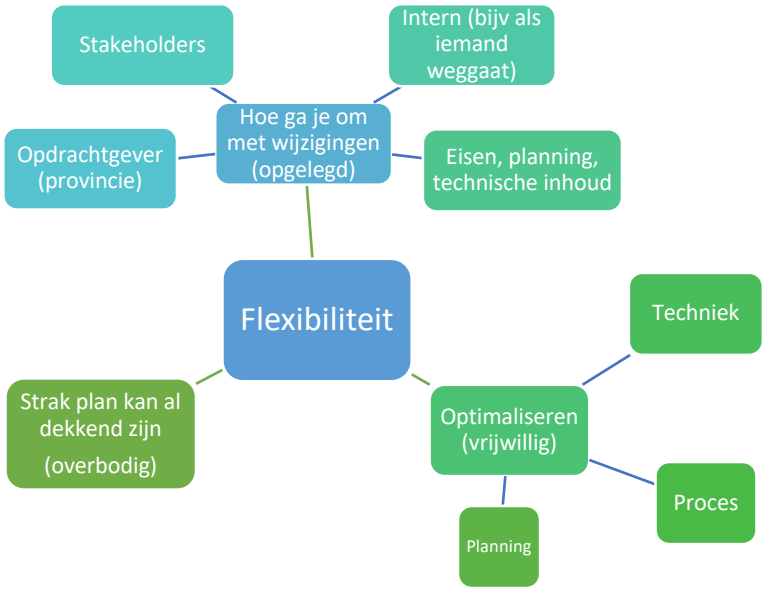


Figure 37 Flexibility web of interviewee A1 - NL

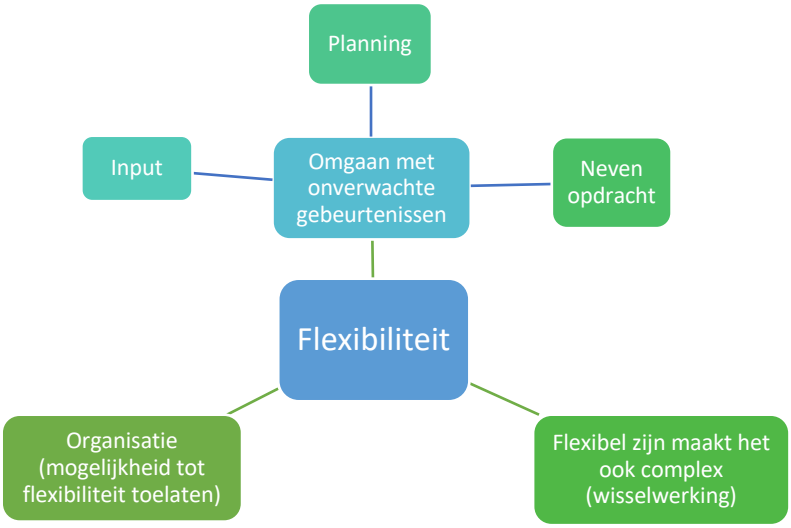


Figure 38 Flexibility web of interviewee A2 - NL

Figure 39 Flexibility web of interviewee B1 - NL

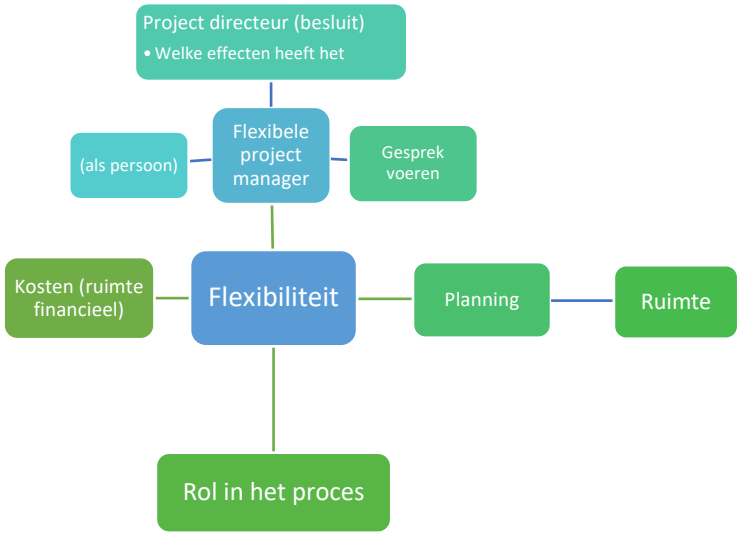


Figure 40 Flexibility web of interviewee B2 - NL

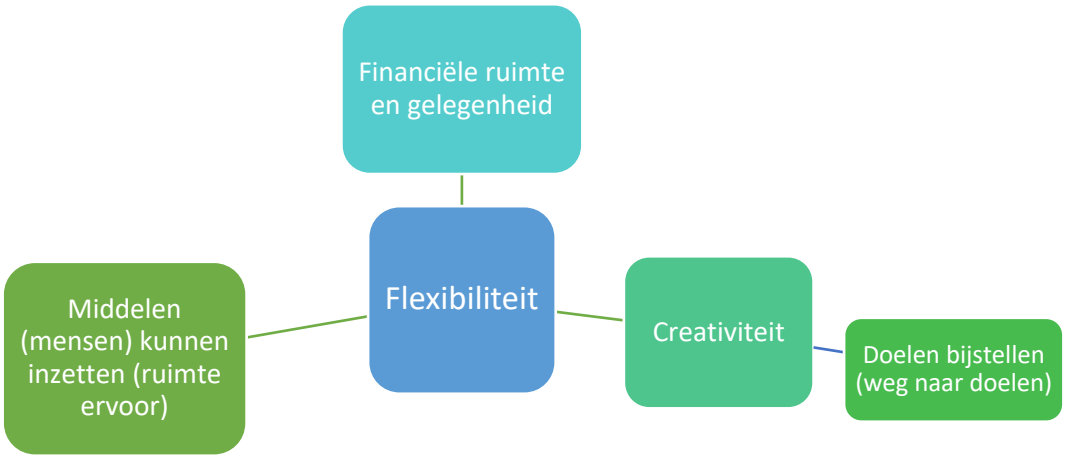


Figure 41 Flexibility web of interviewee C1 - NL

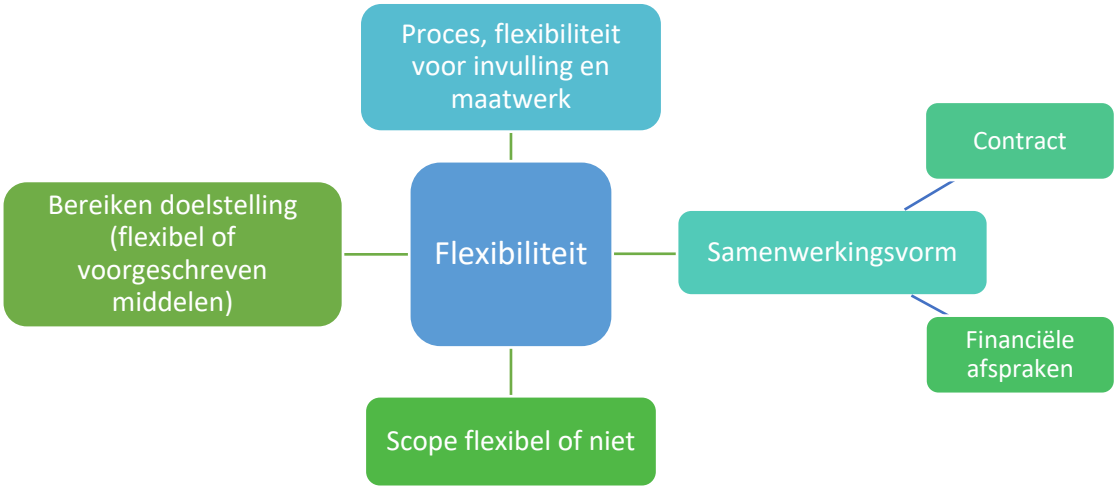


Figure 42 Flexibility web of interviewee C2 - NL

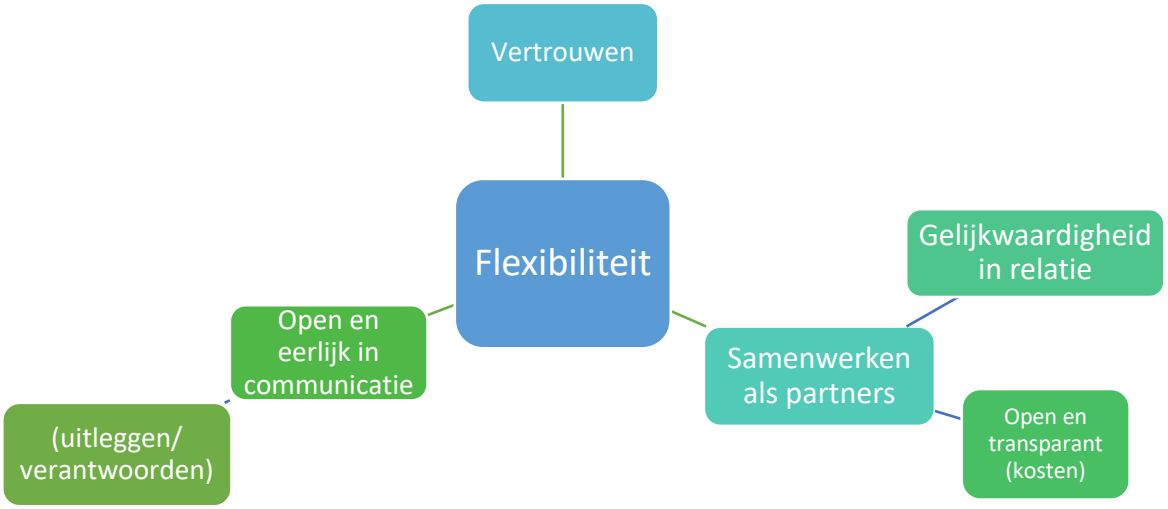


Figure 43 Flexibility web of interviewee D1 - NL

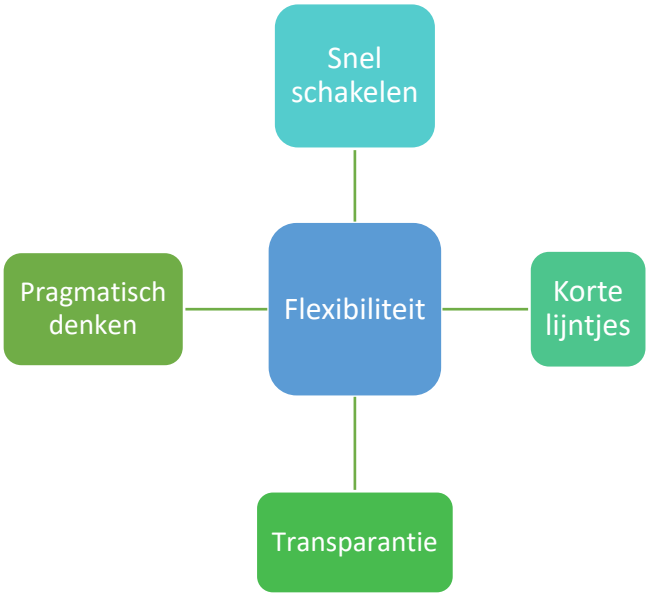


Figure 44 Flexibility web of interviewee D2 - NL

G. Additional information from the individual cases

Case A – Tramline

Project complexity - Technical complexity

Non-alignment of project goals (1&2): The overall project goal was aligned. However, the initial client was not clear on what the goal exactly entailed and therefore goals for the project duration and scope were not always aligned. As a result, Arcadis has hesitated to continue with the assignment and to be associated with the project.

Uncertainties in scope (3&2): The interviewees explain that due to the inexperience of the initial client, the input from the initial client was insufficient and incomplete and that there were many changes in scope. For example, there was not a proper design of the alignment delivered by the initial client. Later, when the initial client delivered a new alignment, it was still inadequate. This affected the work that was done. Because of all the uncertainties that come with the incomplete set of information about what should be done, Arcadis decided to take it into their own hands. The initial client did have strict requirements which were unclear, which made it extra hard to deliver the right thing.

Project duration (3&4): The assignment had a very short lead-time with intermediate milestones. Interviewee A1 says this lead time was set due to the planned out of service period of the tram. Compared to another similar assignment the duration was half of that assignment, which makes it more complex and gave a lot of pressure.

Organisational complexity

Lack of resource and skills availability (2): In the project team, at the side of the initial client, there was a lack of competent people for this project, which resulted in insufficient and incomplete information for the team of the assignment. This meant people needed to be hired to help them with their tasks. For the assignment, much more had to be done than the initial client had ever imagined:

"At the initial client-side, they were unconsciously incapable of doing this kind of project."

Quote of interviewee A2

Interviewee A1 also indicates that it was a challenge to find 60 suitable people for the team and demanded a lot of effort. Subsequently, there also had to be dealt with change in capacities in the team, for example when somebody retired or changed jobs.

Size of project team (3): At the peak time, 60 people were working on the assignment from Arcadis's side. The biggest challenge was communicating and especially with the uncertainties and changes in scope. Another challenge was to keep the whole team motivated and to remain credible in an uncertain situation. When more time would have been available for the assignment, a smaller team would be suitable for this kind of project.

Lack of trust in project team (1&2): The initial client failed to provide information and as a result, confidence was low. In the team with the Engineering firm the trust was high.

Others: There was much uncertainty due to the insufficient information provision. This resulted in a discussion on paying for costs that were made to solve the information problem:

"At a certain point it just didn't work anymore, and we said: it just has to be good and otherwise we will fix it ourselves. Until this day we are still discussing this with the initial client, because they do not want to pay."

Quote of interviewee A2

External complexity

Remoteness of location (1): The location was not remote, although the tramline is long and spread over several cities.

Interference with existing site (1): The tramline is mostly renewed and does therefore not really interfere with other functions. However, the existing tramline does have intersections with other functions, and this must be considered.

Political influence (3&1): The political influence was mostly present because the initial client was a governmental body, which is a different collaboration than with a commercial party. In addition, this project was a point of attention for media and the initial client because a previous similar project did not go as desired.

Variety of external stakeholders' perspectives (2&1): As a contractor, they did not have to do with many stakeholders, only with a few municipalities. Arcadis received a list with external stakeholders for the project and their view on the project was not very different.

Number of external stakeholders (3&1): The 'higher' score is given for the number of external stakeholders related to the project.

Project management approach

Terms of reference (1&2)

The goal was clear and fixed at the start of the project. The budget and schedule are frozen during the execution phase. While the focus was strongly on control and uncertainties should be prevented in terms of reference, many uncertainties could not be dealt with easily.

Task definition (3)

The project organisation was structured via a strict task description and tasks were appointed to specific parties. In the smaller teams within Arcadis's assignment tasks were less specific appointed and collaboration was stimulated. Multiple roles participated in the process of decision making.

Contract (4)

The contract was work-based and there were no complete specifications, price based on rate.

Incentives (4&3)

The idea was to work towards the scope and there was some level of stimulation for the parties to work system based and think and work outside the scope. The achievement of a high level of appreciation from most stakeholders is a focus point.

Change (1)

Changes should be limited as much as possible. Risks on the project were tried to be avoided or constrained.

Steer (2&3)

In the project organisation, the structure was quite hierarchical. Most information was kept at the top and governed by instruction, with some emphasis on information transfer. In the team for the assignment, the structure was more strategic based.

Information exchange (4&3)

The shared information exchange is mostly done informal, open and unstructured. Significant changes in scope or large issues are formalized.

Interface management (5&3)

Interviewee A1 and A2 vary considerably in their scores, this difference may be due to the role and perspective difference. The project manager scored this element high, and the Design leader scored this element average. Interface management was mainly a shared task, and responsibility was transferred to the team participants based on trust and self-control. There were meetings scheduled for the organisation of the project but obtaining information on progress was also done irregular in the team of the assignment.

Flexibility enablers - Selected flexibility enablers

Contingency planning (±&+): There was not a specific contingency planning, however, adjustments have been made to the initial plan. Interviewee A2 points out that different backups for the planning did help to be more flexible.

Seizing opportunities and coping with threats (+&+): Interviewee A1 points out that the decision process was well organized and left room for seizing opportunities and coping with threats. However, due to the time pressure, the incentive to seize opportunities was low. Interviewee A2 says more time would have given room for flexibility and creativity and thereby to better manage the complexity.

Standardise the process and design (+&±): Interviewee A1 sees this as an important aspect in complex projects:

> *"In one discipline with one design report, they can do it how they like it, but with more disciplines it is different. Fourteen different types of outcomes are not desirable and that is why it requires more management. It must be sellable; more process control is needed. So, you have to: Write instructions, write templates, make flowcharts to make sure that everything runs smoothly."*
>
> Quote of interviewee A1

In addition, interviewee A2 says that all kinds of process descriptions are not desirable, then people will be confused about what to do. Standardise the process and design are positive when it is done hands-on when it is properly checked and passed on.

Possible alternatives (+&+): Interviewee A1 indicates that they have worked with working hypotheses where probabilities have been used as input. For working with the working hypotheses, support needed to be created with the initial client. Interviewee A2 mentioned that they always thought of what to do in case of not getting the needed information from the initial client:

> *"Then we had to design something where we did not need that specific information and make conservative assumptions with options possible. The backup alternatives gave peace of mind that a solution would be found."*
>
> Quote of interviewee A2

Notes for flexibility in projects from the interviewees:

- The knowledge and experience of a project manager are valuable: consciously detecting gut feelings and do something with them. PMs need to observe what they can do about their worries consciously.
- Tooling that can help to manage complexity and provide insight into interfaces. Systems helped to structure the complexity.
- Flexibility also entails how people (a team) deal(s) with changes.

Case B – Junction

Project complexity - Technical complexity

Non-alignment of project goals (3): Both interviewees mentioned the overall goal to realize the project was the same for all parties. However, everyone in the team had different interests and visions of how to get to the end of the project. Next to the visions of the parties, the conviction of what the new collaboration should entail differed. Overall, the goal of Arcadis was to make a good plan before execution. The goal of the plan executor was to have everything fixed as soon as possible to have certainty and to carry it out. The initial client wanted to constantly take in all the input (from stakeholders) in the project, even while the parties were already executing the assignment.

> *"In such a construction consortium there are different interests of the parties. In cooperation meetings of the initial client, we discussed those interests. It turned out that parts of the interests were opposed to each other."*
>
> Quote of interviewee B1

Uncertainties in scope (3&1): Interviewee B1 explains in the tendering procedure it was the challenge to win the contract by offering the widest possible scope and later the uncertainty comes whether it is possible to deliver that scope. In addition, the new contract form of Plan, Design and Construct with fixed sum contract came

with uncertainties for the parties of the consortium. For instance, the plan executer had to price the execution phase while the planning phase still had to be completed. Interviewee B2 says that there was uncertainty about who was responsible for certain tasks. In addition, interviewee B2 states the fixed sum contract made the team of the assignment avoid scope changes, while the initial client was still talking to stakeholders to see what should be taken into the project.

Project duration (4&3): The duration of the project and assignment was long and therefore also complex according to the interviewees. The duration of the project became increasingly longer due to changes. The longer duration affects many aspects of the project such as costs and a longer process that is needed. Also, the duration of this project was less flexible due to the multi-year program for space and transport infrastructure (MIRT) that has schedules that we must comply with and funds that become available at certain times.

Organisational complexity

Lack of resource and skills availability (1): Interviewee B2 indicates in the team for the assignment there were enough resources and skills available. However, on the client's side, they did not have enough skills and resources to test everything. On top of that, it was clear that the client's knowledge and experience for this new contract was lacking.

Size of project team (3&4): The team for the assignment was 150-200 people and they all had to communicate with each other.

> *"Many people were involved in the team. The challenge was: Keep all frogs in the wheelbarrow. Keeping everyone involved and informing everyone was a lot and that was complex because it had to be done in a fairly short time."*
>
> Quote of interviewee B2

Lack of trust in project team (1&2: Interviewee B2 explains in the team of the assignment there was limited trust, you had to take in that every party had a hidden agenda and its interests. At Arcadis's side, there was trust in the team. On the way, the client did lose trust in the executing part of the team of the assignment because they felt their wishes were insufficiently translated, and that was because the executing part of the team had no more space, time and financial wise. After all, they had made their wishes known too late, according to the interviewees.

Others: Both interviewees refer to the contract type in different elements for complexity. The type of contract contributed significantly to the projects' complexity. For the first time, a Plan, Design & Construct (PDC) contract was used. Parties were unfamiliar with this way of working and that required a great deal of effort. This also meant that several parties worked together who are not familiar with working together and also have different working cultures.

External complexity

Remoteness of location (1&3): The location of the project is only easy to reach by car, not by train. The client and the team of the assignment worked in different locations. The location of the team of the assignment was within walking distance to the client but also not easy to reach by train. Interviewee B2 says that keeping short lines of communication between the whole project team was difficult due to the difference in locations.

Interference with existing site (4&3): The project is mainly an improvement of the old situation and does not involve much new ground. However, an important requirement of the client is a safe and continuous traffic flow during construction which put pressure on the buildability of the project in the planning phase. That made it difficult to think of good solutions to make construction work and traffic flow possible.

Political influence (2& 4): Interviewee B1 scored this element on the low side for contributing to the project's complexity and says mainly changes in regulations affect the project much and result in a delay. Interviewee B2 scored the element higher because the project was under a magnifying glass due to its' function as an important motorway junction and because a new contract form was used in the project. Mainly the client needed to deal with the political game that took place in The Hague. To keep the politicians in The Hague

informed on the process, a lot of effort was necessary such as conversations, consultations, records and reports.

Variety and number of external stakeholders' perspectives (4&3): Interviewee B1 and B2 both indicate how many stakeholders were involved and everybody had their background and interests to bring to the table.

Number of external stakeholders (5): Many external stakeholders were present in the project.

Project management approach

Terms of reference (2)

Most of the purpose of the project is fixed and defined from the start of the project. There is some extension possible but that is avoided by the team of the assignment. Uncertainty is tried to prevent with sufficient analysis in the early phase of the assignment.

Task definition (3)

There is a strict task description for the parties and those tasks are appointed to specific parties and participants. Collaboration is stimulated and decision-making is done together with multiple roles.

Contract (5&4)

The contract form is PDC (Plan, Design & Construct) where different kind of parties are stimulated to work together. The contract has two parts, one where the focus is on collaboration and one where the focus is on working for a fixed sum. There are some specifications given.

Incentives (5&3)

The scope is broadly given by the client. However, throughout the project there is a focus on taking in all the stakeholders input to be highly appreciated for the project. The parties have confidence in the success of the project.

Change (2&3)

A level of uncertainty is mostly accepted by the client. The team of the assignment wants to prevent most changes and there is an emphasis on control. The focus is on the planning phase, but some changes are applied when the benefit is significant for the project.

Steer (3&4)

The approach in the structure of the project organisation tends to be more network oriented. However, there is a certain level of autonomy. Emphasis is put on information and advice.

Information exchange (2&3)

Most information transfer is done formally, there is a certain level of trust that the information will be transferred openly when necessary. A standardised form is used to communicate agreements, notifications or significant changes.

Interface management (3&2)

The task of the interface manager is a function with the corresponding responsibility. In specific disciplines or work teams, interface management is a shared task. There are regular meetings to discuss progress and decisions with the organisation.

Flexibility enablers - Selected flexibility enablers

Contingency planning (?&±): Interviewee B2 mentioned there was a contingency planning, which can be helpful but also has its downside that people take into account with their work that there is a plan b to fall back on.

Seizing opportunities and coping with threats (+&+): In the project was not much room for seizing opportunities and coping with threats. Both interviewees indicate that there was tension because parties individually tried to seize opportunities and coped with threats to being able to succeed in the project as a party within the set

boundaries of the client. The interviewees do see this point as a good point for flexibility in projects and interviewee B1 illustrates a method executed:

"An optimization week had been organized by team realization and team technology. The whole team tried to come up with smart things to bring down the construction costs. Then proposals were made, and decision-making had to take place internally. When we could not do it independently, then a decision had to be prepared so that we would include the client."

Quote of interviewee B1

Standardise the process and design (+&+): Interviewee B1 states that with one team there should be one design/template. In the project, this was done with systems engineering (in Dutch: SCB - Systeemgerichte contractbeheersing). Everything got verified against requirements and there was a verification form for when something was delivered.

Possible alternatives (?&±): This aspect was not much discussed with the interviewees. Interviewee B2 warned that it, above all, needs to be kept under control.

Case C – Highway

Project complexity - Technical complexity

Non-alignment of project goals (1&0): The goal of the project was clear for both parties, however, the parties had different ways to achieve the goal. Also, goals defined in the tender might differ from the goals in the execution:

"A fixed sum contract was offered. We partly read something different in the request of the project than the client intended. We entered a fixed sum tender in competition. Then you are forced to make assumptions and explain it to your advantage, and as soon as you validate with the client it becomes clear that the interpretation differs greatly and that they expect much more than we had foreseen. That leads to discussion and that makes the contract somewhat complex."

Quote of interviewee C2

Due to the fixed sum, the focus of Arcadis' team shifted to costs instead of goals/client wishes. During the project, the client decided to market the project completely different, which was not aligned with the goal of Arcadis since a lot of work had already been done.

Uncertainties in scope (0&4): The difference in scores can be explained by the different interpretation of this element by the interviewees: there is the scope of the project and the scope of the assignment. The understanding of the scope of the assignment differed at the start since the tender phase was won with a different interpretation than intended by the client. The fixed sum entailed Arcadis keeping the scope to stay as limited as possible.

The size of the project was such that it created uncertainty about what exactly was in the scope. The client realized only during the project that scope management was crucial since there were unclarities in which objects still belonged to the scope.

"What is covered by the contract, what needs to be worked out and where does that financing come from? Until very late in the project, there was uncertainty as to what belongs to that physical scope."

Quote of interviewee C2

These uncertainties meant that we had to wait to record things and that changes had to be made until late in the project.

Lastly, technical feasibility played a role. For example, it would make a big difference whether a bridge had to be modified or replaced

Project duration (3): The project duration itself was quite long. Despite the scores of the interviewees, the project duration does not contribute much to the project complexity. However, the project duration was partly a result of the complexity.

"It took longer because the project complexity manifested itself"

Quote of interviewee C1

Others: Interviewee C1 explains the project is divided into **two parts for the contracts** of the assignment. The first contract includes a maintenance component and is a DBM-contract (Design Build Maintain). This DBM contract is not based on DBFM-standards (Design Build Finance Maintain) but on UAV-GC standards, which means that **new guidelines** need to be written (partly). Which is also a piece of technical discipline that Arcadis must deliver.

Organisational complexity

Lack of resource and skills availability (1&3): Interviewee C2 indicates that there were very experienced people on the project from the start, but they were relatively inexperienced in drawing up these kinds of large contract files and managing this kind of project. Find the right people for the job was not easy. During the course of the project, the right people had been placed in the right place.

"At the start of the assignment we were a large ship with people, who normally stoke the ship with coal, were now suddenly at the wheel."

Quote of interviewee C2

Size of project team (3): The complete project team was large and different parties were working on different parts of the project. For the assignment, in particular, the team of the client was large, in addition, Arcadis had a team of 70-80 people at peak time. In total, a minimum of 100 people was involved from Arcadis's side.

"Purely the size of the team does not directly affect complexity. Rather, it is the solution to complexity."

Quote of interviewee C1

Lack of trust in project team (1&2): At the start, due to the lack of resource and skills availability the trust in the project team was low. Also, not everyone works equally independently, with the same ethics, etc. which also results in different levels of trust in the team.

Parties worked simultaneously, and the integrated planning and integrated management was the responsibility of the client. This made it difficult for Arcadis to gain insight into where they are working towards, what are the milestones and what process the project was currently going through. Due to this lack of information and communication from the client, a lack of trust was established.

Others: There are two project parts for the contracts for our assignment. The first contract includes a maintenance component and is a DBM-contract (Design Build Maintain). This DBM contract is not based on DBFM-standards (Design Build Finance Maintain) but on UAV-GC standards, which means that new guidelines need to be written (partly). Which is also a piece of technical discipline that Arcadis must deliver.

The project was won with a fixed sum contract and is later changed to a directing contract. Later in the project the contract was changed to a two-phase contract.

External complexity

Remoteness of location (1&2): This is not seen as a relevant factor for contributing to the project complexity. However, interviewee C2 does indicate that working together in one location near the project location is an important factor for better collaboration.

Interference with existing site (1&2): The project runs through various municipalities and therein pieces of land owned by private landowners. However, this does not contribute significantly to the project complexity.

Political influence (3): The client is a governmental agency and must justify politically what they do and that continuously plays a role in the background. The project team is not directly affected by that, but the project manager of Arcadis is because he is in direct contact with the client. An obvious example of political influence is the director-general that decided that the market approach needed to change, resulting in work that had been done should be adapted or redone.

In another way there is also political influence, some parts of the scope have a legal status which means that there are all kinds of restrictions on what you may do with those parts, for instance, a river dike has such a status and cannot be adapted without permission.

Another political influence that contributed to the complexity of the project, was the effect of the report of McKinsey that was published in 2019. The report is about the risks (distribution) for contractors in large construction projects. This made the assignment switch to a two-phase contract, while they were already quite far with the assignment. How to implement the new contract needed to be studied together with the client and resulted in more work and new tasks. This brought many new challenges:

> *"Then the question is: Where exactly do you start? This assignment comes suddenly, it surprises us. What must all change in the contract file? And how do we ensure that we do not overlook anything? How do you take people along and how do you ensure that people do not lose their work ethic and become demotivated?"*
>
> Quote interviewee C2

Lastly, there is also a lot of influence from the stakeholders. The provinces and municipalities also wish and/or claim things and that influences the scope.

Variety of external stakeholders' perspectives (3&2): Stakeholders were lobbying for their agenda which could expand the scope, and this ensured that if no decision has been taken, Arcadis had to wait with continuing work.

Number of external stakeholders (4): There were many different stakeholders present in the project and a lot of stakeholders take part in the decision-making. During the project new stakeholders became involved, this was partly because of the scope uncertainty.

Project management approach

Terms of reference (2&3)

The aim of the project has remained broadly the same throughout the project. The definition of the scope was clear and set. However, due to scope uncertainties, changes needed to be made while these changes were not desired.

Task definition (3)

Arcadis has a strict task as explained in the general description of this project: preparation of the contracts and facilitating the agreements with stakeholders. In addition, Arcadis also helps the client with the tendering process for these contracts. Multiple roles participate in the decision-making process.

Contract (2)

The contract was a fixed sum contract. During the project, there was a small change to a directing contract. Most was fixed, such as specifications, dates, target prices.

Incentives (2)

The focus was on realizing the scope of the project. However, some input in the scope is possible but not encouraged.

Change (3)

Uncertainties are mostly avoided with an emphasis on front-end development. Some level of uncertainty is accepted, which entails that changes, rework and iterations are accepted. There is the possibility to search for improvements in the project.

Steer (4&3)

In the beginning, a more strategic approach is applied. The organisation is more network-oriented, especially later in the process. There is an emphasis on informing and advice instead of instructions and decisions. Collaboration is stimulated and there is a small level of autonomy present within the project team where not all actors are involved in all decisions.

Information exchange (4)
Most information exchange is done informal, open and unstructured. Only significant changes are formalized with an 'entry check form'.

Interface management (4&3)
There is a slight difference between the start of the project and later in the project. An interface manager was assigned, but interface management was mostly a shared task. In the beginning, there is some level of trust and self-control, which expands later. There are some meetings to discuss progress and decisions with the rest of the organisation. The project manager gets informed by the actors about the progress and decisions made on an irregular basis.

Flexibility enablers - Selected flexibility enablers
Contingency planning (-&+): Interviewee C1 does not think of contingency planning as a relevant flexibility enabler, later in the project having a plan B did not play a big role. Interviewee C2 addresses this enabler as very important. Several milestones have been exceeded which implicated that the schedule would not be met.

"The moment that you start running behind, the only way to take in contingency is by rigorously changing the schedule and moving milestones forward so that you can also start planning that space. That would certainly have been an enabler to meet schedule."

Quote of interviewee C2

Seizing opportunities and coping with threats (+&+): Both interviewees see this as an important aspect. Interviewee C1 indicates that risk management is part of the assignment and must be incorporated and that there is no more room for seizing 'extra' opportunities for Arcadis during the project. Interviewee C2 indicates that they did seize many opportunities to get work in the project assigned to them instead of other parties at the beginning of the project. Also, together with the client, opportunities are seized. For example, additional research for flora and fauna is done and for working with the exemption from the nature management law to prevent potential delays in the realization phase.

"Risk control of which together is decided that it should be done, was not part of the question, but it arose from 'how complex is the task?' and 'what information do we already have?' well that is not enough, and we have to do additional research and if we are busy then we have to, in any case, apply for exemptions in high-risk areas. For example, you discover a risk, and you collect the opportunity there to manage that risk."

Quote of interviewee C2

Standardise the process and design (?&+): Only interviewee C2 mentioned this enabler relevant. On several levels, Arcadis tried to standardise the process and design. Some examples are standardised templates, the system to work in at the side of Arcadis and process in terms of quality. The design was also standardized where relevant, there were several unique structures and parts in the design that are tailor-made.

Possible alternatives (?&+): This was one of the MEAT (Most Economically Advantageous Tender) promises of Arcadis. Interviewee C2 explains the moment a deviation or a serious change was to arise, and they were in danger of not meeting milestones, they would look at alternatives of how it could be solved. Interviewee C2 states it is certainly a good flexibility enabler to reduce costs or to save time, to look for alternatives. For example, working on plan A and parallel working on plan B to not lose time when plan A does not work.

Notes for flexibility in projects from the interviewees:
- Inconvenience in terms of projects and flexibility: the classical view is not flexible. A project definition is not flexible.
- As a contractor, they worry whether the client is willing and able to execute projects and assignments more flexibly. Interviewee C1 experiences tension of a fixated tender from the client and need for flexibility in executing the assignment.
- Individual willingness and competence to be flexible plays a role.

Case D – Workshop for trains

Project complexity - Technical complexity

Non-alignment of project goals (2&3): The client had commissioned an open question wherein the exact goals of the project were uncertain. The project was to be executed with a group of expert organisations, such as Arcadis, an architect and researchers. To find out what the workshop of the future should entail the parties sat down together. Interviewee D1 mentioned that the outcome of the discussion with the parties was different than expected, everybody brings a different point of view to the table.

Uncertainties in scope (4&2): The open question from the client came with a lot of uncertainties for the scope. Interviewee D1 indicates that for this project they had to think for the future which brings a lot of uncertainty in what the scope should entail exactly. Next to that, a connection had to be made between two different techniques that come together in a security system, something that has never been done before. Interviewee D2 referred to the uncertainty of demarcating the scope with different parties and deciding which party was going to do what. Also, during the project, the scope for Arcadis expanded, this did not contribute to the complexity.

Project duration (2&1): The duration of the assignment and project was not very long and because there were no determined follow-up steps with a specific date the duration was not under pressure.

Others: Interviewee D1 explains for this project many new challenges were present, mainly in the field of technology. Different techniques had to be brought together to make a universal and integral design suitable for all different trains and new techniques had to be realized to deal with unexplored areas. Also, they had to think further than how processes currently go.

Organisational complexity

Lack of resource and skills availability (2&1): In the project team, much different expertise was present. When they needed more expertise, they consulted the specific party from that expertise. Therefore, there was no lack of skills availability.

Size of project team (1): The project team consisted of the client in combination with the team of the assignment. The team itself was despite the different parties small, less than 20 people.

Lack of trust in project team (1): Interviewee D1 says there was trust in the team that the assignment could be completed. Interviewee D2 indicated that by means of meetings everybody was involved and kept informed. In addition, good agreements had been made about which parties performed which tasks, which was experienced positively by interviewee D2.

Others: Interviewee D2 explains it was contractually complex because of the cooperation with various parties and a scope that was unclear at the start. They needed to figure out what the project would entail and then what the scope of the parties in the assignment would be.

External complexity

Remoteness of location (3&1): Interviewee D1 indicates that accessibility was a point of attention from the start because the project location was in the middle between two tracks. Creative solutions had to be found to make the project accessible during execution and for the design of the final project logistics.

Interference with existing site (4): Both interviewees agree that there was no interference on the greenfield itself, but the interference was present for accessibility and connections to the current tracks and the stabling area. Their score was indicated as high because the existing project location left little leeway for accessibility solutions. Interviewee D2 emphasizes the high degree of overlap in the project with the direct environment.

Political influence (3&4): Interviewee D1 explains that because the project would be realized on a greenfield, they had to do with a zoning plan change and a change of the environment in the area, which affects the plans of municipality and province. Because of the size of the workshop, communication and commitment from external stakeholders were important, therefore a press release was strategically done to get commitment from other parties, explains interviewee D2.

Variety of external stakeholders' perspectives (3&4): Stakeholders seem to lack to know what they do want; they mainly know what they do not want explains interviewee D1. Interviewee D2 indicated that in this phase of the project the external stakeholder perspectives did not affect the project much directly, but indirect you already must take their views into account. In addition, this indirect effect meant that we could not actively inform, but had to try to respond to it

Number of external stakeholders (4&3): There were many external stakeholders involved. Interviewee D2 explains they had to do with residents, the environment, companies in the area, municipality and province.

Project management approach

Terms of reference (5&3)

The scores of the interviewees differ for this element. This difference can be explained by the point of view that they have taken with scoring this element. Interviewee D2 based the scoring on the contract form of Arcadis, which was a fixed sum contract with possibilities to some degree. Interviewee D1 scored this element based on the (open question) assignment they got from the client, which was to design a workshop of the future.

Task definition (5)

The tasks are roughly defined to stimulate collaboration and creativity. In the team, the roles are shared, and everyone feels the importance to participate in the decision-making process.

Contract (5&3)

For this element, the same difference can be found in scoring as for the first element. Arcadis had a fixed sum contract for the activities of the company. For the whole of the project, the focus was on the realization of functions.

Incentives (5)

The attitude towards the project is very positive and the team had trust in a positive result of the design for the goal of a workshop of the future. Incentives for the contract are system output based.

Change (5&4)

The project team is open to changes and changes need to be facilitated. Because of the (scope) uncertainties, rework and iterations are expected. Risks are seen as opportunities and are exploited. In the organisation of Arcadis, there is however some limitation to the level and number of changes depending on the contract.

Steer (4&5)

The structure of the project is network oriented. The emphasis is on information and advice instead of instructions and decisions. It is about the social process with the team and collaboration with all actors. There is some autonomy present and not all decisions are made with everyone.

Information exchange (4)

Sharing of information is mostly done informally within the project organisation. There is trust that the needed information is present in the organisation. Significant changes or large issues are formalized.

Interface management (2&4)

All actors are responsible for the interface management in the team, the project manager is ultimately responsible. There is trust in the team the interface management is covered and the project manager is regularly informed on progress and decisions.

Flexibility enablers – Selected flexibility enablers

Contingency planning (?&-): Interviewee D2 states that a contingency planning was not relevant because they worked with a living document and says that in another situation, for example with strong dependencies, it might be relevant.

Seizing opportunities and coping with threats (+&+): Both elements of this aspect are seen as very relevant by the interviewees. Interviewee D2 indicates that the client had an open attitude towards opportunities and when ideas were suggested they could be explored whether they fit into the project.

> *"We seized every opportunity that arose. There was also room for that. That's because you're researching and solving the question of the client, not the solution itself. If the solution is set, then that space is not there. That means that you have to revisit the decision-making that has taken place."*
>
> Quote of interviewee D1

Both interviewees explain that because everything was well documented throughout the project, they had insight into the situation which meant they could anticipate easily on the relevance of risks the whole time.

Standardise the process and design (±&±): The interviewees explain that the standardization was reflected in the process in the agreements made and in the list of actions, decisions, risks and opportunities. Interviewee D2 indicates that this phase of the assignment might be too abstract for more standardisation. Interviewee D1 explains that the parties delivered information in a format suitable for the receiving party, but not standardised, this was organised by means of constant communication.

Possible alternatives (+&?): Interviewee D1 explains that they made use of possible alternatives at the beginning of when decisions needed to be made. This was included in the strategy to work from coarse to fine by weighing up variants. This way of working with variants was sufficient for this design phase.

Notes for flexibility in projects from the interviewees:

- Interviewee D2 addressed that with public companies, which are bound by enormous procedures and protocols, you quickly get that bureaucratic tint to the project. When that is not the case, you have room to be flexible and to be able to respond to certain current events.

H. Operationalised flexibility enablers

This list contains the operationalised flexibility enablers found in the documents, observed by the interviewer in the interviewees while discussing complexities and explained by the interviewees while discussing flexibility enablers.

Self-steering of the (complete) project team (element with different interpretation of interviewees)

- Draw the hierarchical structure in which the specific workflows can work self-steering
- In the offer to the client, the team for the assignment should be presented as partners, where everybody is equal

Open information exchange among different groups

- An integrated system with the project team
- The project site in OneDrive
- Weekly sessions with the team
- Establishing a common project culture and rules of how to interact
- Creating the security to be vulnerable
- Communication with the client on regular basis (use examples to clarify situations)
- Creating short lines between the parties by regularly communicating
- Agreements on how to communicate and how to deliver things to each other

(Shared) interface management (element with different interpretation of interviewees)

- Requirement control matrix
- Experience and gut feeling of people who can estimate which interfaces there are
- Interface sessions, whereafter tasks are delegated (and assigned in a system)
- Interface manager is fully dedicated to that job, for overview and end responsibility
- LEAN planning to identify interfaces with the team
- Visualise interfaces and dependencies (in the design 3D)

Contingency planning

- Different back-ups for the planning

Seizing opportunities and coping with threats

- Optimization week on a topic: make proposals and decisions or prepare to discuss with the client
- Discuss additional risks (and opportunities) with the client
- Open question from the client as assignment description
- Be well documented throughout the project to be able to anticipate and react
- Bring in experts to orientate towards possible solutions and to gain insight into certain risks

Trust among involved parties

- Cooperation coach
- Kick-off with informal and formal part (on project location)
    - Discuss starting points
- Establish cooperation rules
- Regular meetings/extra meetings (collaboration meetings)
- Prevent people from key positions leave, for knowledge and team
- Work on one location with the project team
- Fulfil obligations and be open and honest when something does not work out, report as soon as possible including a proposal for a solution
- Asking open questions and being open to the reaction
- Make sure you have confidence in the project yourself
    - Change agreements for the contract when needed
- Communication and starting the conversation yourself when something is wrong

Standardise the process and design

- Write instructions, templates
- Make flowcharts
- Hands-on managing of standardised aspects (actively checked and passed on)
- Systems engineering (SCB)
- Standardised process in terms of quality
    - Verifying everything against requirements
    - Verification form for when something is delivered from another party
- One system to work in
- One list for actions, decisions, risk and opportunities for the project

Visualised project planning and progress

- LEAN planning on the wall
    - Combined with a daily stand to discuss progress
- Get the right people on the team for managing planning and process, structure and visualize based on experience
- Visualised communication
    - Presentations (PowerPoint)
    - Use visualisations
- Visualise relations in a web or breakdown structures (helps discover interfaces)
- Design visible
- Common thread sessions to visualise and keep track of the tasks, the planning and most important milestones, the common thread of the assignment.
- Sticker sessions to align what needs to be done

Possible alternatives

- Working hypotheses with probabilities
- Work parallel on plan B to not lose time when plan A does not work
- Work from coarse to fine: weigh up variants

Network structure (rather than) hierarchical structure (element with different interpretation of interviewees)

- Alliance with the parties on the assignment
- Asking open questions
- Allow people to take initiative
- Organisations need to be able to facilitate a network structure

Continuous learning

- Know whom you need on the team (based on knowledge, via via and get to know people)
- Balance experience in the project team (enough experienced people)
- Evaluations (between phases, between milestones, peer review, moment for in each meeting)
- Construction reflections
- Learning trajectory for inexperienced with the experienced to contribute to their development

Other enablers from cases

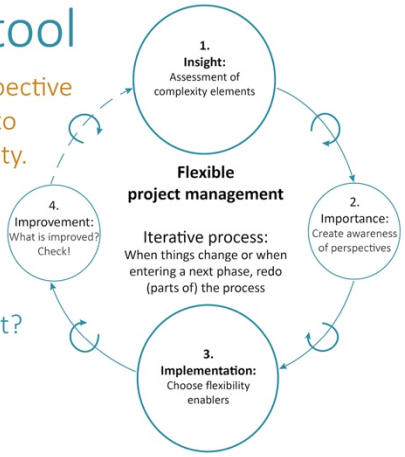
- **Create support in the team:** discuss with the team how to solve an issue and explain what is happening and decided to the team.
- **Motivation**: Personal responses to people's feelings with personal attention and Cooperation/team games
- **Coping with different interests:** inventory, assess and prioritise. Make a plan to deal with the relevant interests. Decide together in consultation. In addition, weekly core team consultations can be held to keep discussing and serving the interests of all parties.
- **Communication with the environment:** inform and involve the environment via a digital EIA.
- **Transparent planning:** Gantt chart that becomes more of a flowchart to make the sequence of steps clearer, to share most important milestones and to show the main process on an abstracted level.
- **Functioning project team:** decide to replace and/or relocate people when they turn out not suitable for the job
- **Working together when there is not one location to work for the (design) team:** a principle 2x2 can be applied, which means that every two weeks the parties sit together for two hours to work together
- **External stakeholder commitment:** communicating at an early stage with external stakeholders and for instance, a press release can help to inform the public on plans.

I. Initial Flexible project management tool

Flexible project management tool

Gain insight into the boundaries of the project and the perspective of the team. Choose the operationalised flexibility enablers to increase flexibility to (better) cope with the project complexity.

-> For more information about the use of the tool, see page 3.



Own illustration based on Jalali Sohi (2018)

1. Insight: Assess complexity elements

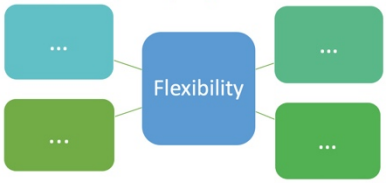
Which elements contribute to the complexity of your project?

- ☐ Dependencies between tasks
- ☐ Involvement different technical disciplines
- ☐ High project schedule drive
- ☐ Interfaces between different disciplines

2. Importance: Create awareness of perspectives within project team

How does the team think about flexibility in managing complex projects?

- ☐ Co-create a word web to discover the perception of the team on flexibility in managing project complexity



3. Implementation: Select flexibility enablers

A. Which flexibility enablers are relevant for the project?

- ☐ Open information exchange among different groups
- ☐ Trust among involved parties
- ☐ Visualised project planning and progress
- ☐ Continuous learning

B. Select the operationalised flexibility enablers that match the selected flexibility enablers, you can find them on the next page. Operationalise these enablers in your project.

4. Improvement: Check what is improved!

Check what is improved after each important milestone. Evaluate the complexities that arise in a new phase and redo the process to keep optimizing.

3B - Operationalised flexibility enablers

Open information exchange among different groups

- ☐ One 'project site' with the project team (relevant with multiple parties in project team)
- ☐ Integrated system with the project team (relevant with multiple parties in project team)
- ☐ Establish a common project culture
  - ☐ Rules on how to interact
  - ☐ Rules on how to deliver things to each other (as parties in project team)
  - ☐ Create the security to be vulnerable
- ☐ Weekly meetings:
  - ☐ Planning board sessions with the project team (short lines of communication)
  - ☐ Standups within the organisation
- ☐ Conversations with client regularly

Trust among involved parties

- ☐ Make sure you have confidence in the project yourself (contract/planning/agreements)
- ☐ Change the agreements of the contract when this blocks trust
- ☐ Prevent people from key positions to leave (by selecting team members that can commit)
- ☐ Kick-off with an informal and formal part, preferably on the location of project
  - ☐ Informal gathering, to get to know the team
  - ☐ Formal part to discuss cooperation rules and expectations
- ☐ Work on one location with the project team
- ☐ Plan regular meetings and sessions together (evaluation sessions etc.)
- ☐ Hire a cooperation coach for the project team
- ☐ Be honest and report when things do not work (and propose a solution)
- ☐ Ask open questions to the team about the progress of work and their personal life

Visualised project planning and progress

- ☐ Get the right people on the team to visualise and structure based on experience:
  - ☐ Planning (to achieve the right level of abtractness in the planning)
  - ☐ Process
- ☐ Facilitate a LEAN planning on the wall
- ☐ Daily stand to discuss the progress (at LEAN planning)
- ☐ Make the work visible (by showing progress/design on screen or printing every week)
- ☐ Sticker sessions (to visualise and align what needs to be done)
- ☐ Common thread sessions
- ☐ Use visualised communication (i.e. by using a powerpoint presentation with visualisations)
- ☐ Visualise relations (in a web or (system) breakdown structures)

Continuous learning

- ☐ Learning trajectory in which experienced involve inexperienced
- ☐ Balance experience in the project team (enough experienced people)
- ☐ Know who you need in the team (based on knowledge, via via and get to know people)
- ☐ Evaluate (between phases, between milestones, in each meeting)
- ☐ Reflections on the executed work

2/3

Tool explanation- step by step

Introduction

When a project team starts with a project, usually a plan is developed for managing the project. In this phase, it is advised to start using this tool. For project teams at Arcadis, this means that in 'The Arcadis Way' this tool should be incorporated in the process 'Deliver to Result' in the step 'Plan project'. This can be incoporated in the Project Management Plan (PMP). This tool has been scientifically created and the limitations of the scope should be taken into account.

Use: The tool has been developed to use for the management roles in the project.

Goal: Create awareness of the complexities and opportunities to incorporate flexibility in the management of the project.

1. Insight: Assess complexity elements

By detecting complexity elemens, insight can be gained into the project complexity. It is important to be aware which complexitity elements contribute to the project complexity. In this step the complexity elements can be selected. When other complexity elements are relevant, discuss this and check whether the flexibility enablers could be applied.

Duration: 2 min
Goal: Select the elements that contribute to the project complexity
Who: Project manager(s)
How: Based on own experience and/or consultation of the project team

2. Importance: Create awareness of perspectives within project team

To understand how flexibility is perceived, a word web can be composed with the team. It is important to pay attention to what the team finds important, to select the right flexibility enablers in the next step. When the team is not aware of certain flexibility possibilities, support can be achieved be explaining the chosen flexibility enablers.

Duration: 15 min
Goal: Create a flexibility word web that visualises what the team thinks of flexibility
Who: Project manager(s) with the project team
How: Plan a short session and make a word web (for instance in PowerPoint)

3. Implementation: Select flexibility enablers

To use flexibility enablers suitable for the project, it is important to select flexibility enablers based on the two previous steps. Choose the enablers that need to be operationalised to increase flexibility in the project.

Duration: 20-30 min
Goal: Select the flexibility enablers in step A. Operationalise these enablers in B.
Who: Project manager(s)
How: Determine the enablers that have the potential to contribute to flexibility in the project (incorporate them into the PMP)

4. Improvement: Check what is improved!

To learn from each step in the process, it is important to check what has improved after applying flexibility enablers. This reflection moment can be organised after a significant project change, a milestone or a new phase. Additionally, it can be good to do intermediate checks whether the chosen flexibility enablers are the right enablers and whether they help enough in coping with the selected complexities.

3/3

J. Comments on the initial tool

After the experts scored each element of the tool, the different elements were discussed. After, a discussion on the usability of the tool, in general, is held. From the discussions, the comments are presented per element.

1. Assess complexity

- Use in the substantiation that not all complexity elements are included in the list with complexities
- It is compact and, in that sense, easy to use
- "High project schedule drive" didn't mean much to two experts. For them, "high pressure on project schedule" would be clearer. (Other experts did understand it and one used it in a project)
- The demarcation could be more clearly in step 1, when is this tool really useful and when not.

2. Create awareness

- The soft side of skills and getting people started is very important. So, this form can be used as one of the possibilities to start a discussion about this at the beginning of the project
- The form is very good because you get to know your team about what they mean by flexibility.
- What may help in terms of content for the PM, who has the tool, is a shadow list with what flexibility could all be, based on the literature research, to be able to peek if the conversation does not get going and mention something like "Have you ever thought of this?"
- We are used to holding risk sessions regularly, so for many people, it could become a bit like a risk session-like meeting. So it is also good to make a distinction in that, which is different in such a session than in a risk session
- Sounds like a part of the kick-off
- There are several ways in which you can make such a word web, for example in Mentimeter
- A session on flexibility can also help very well to set up your project properly. For example, if you see that those stakeholder relationships in your project are or will become very complex, then you know that you must put a good line in it. This can be included in such a session on flexibility
- One expert has mixed feelings: It feels like "I have a tool in A4, but now I still have to add something". Other experts see it different:
    - Compare it to doing a risk session with the team, then you also make a list or something extra. It is more of what you pick up and how you then use or can apply it
    - See it more as a tool that helps you get to know people. It is not a binding and all-embracing overview.

3A. Select flexibility enablers

- It is a very limited list
- To be complete is a utopia
- This simply applies to any project; it is always important. So, in that sense, this is not a choice menu
- Your project characteristics lead to you ticking something. So, if I am on a project where open information sharing is all well organized, I will not check it here because that has already been arranged. But then I would tick what is relevant

3B. Select operationalised flexibility enablers

- These options are the value of your tool
- I think it is very useful, but I also see things that are standard for us
- 'One project site': this can also be done in teams, where you can also combine other organizations
- Arcadis must be careful not to have too many of those kinds of collaboration tools on projects because then the information will be in different tools, but that is something beyond this session
- The added value could also lie in the fact that you jointly look for clevernesses in your project to be truly flexible. That is of course also very project specific. But perhaps it would be good to include the category 'others' in this list, to let it be known that it is an incentive to think about this, but that projects can also think about this themselves very well
    - Yes, it is a bit of customization and we are all stubborn project managers and we all have stubborn colleagues, so that is also a bit of flexibility in the tool. Sometimes you want to name a thing and it is just not listed
- Include a risk pot (preferably shared with the client) in your project as standard in the context of flexibility.
- There are terms in the tool unknown, where can the explanation be found (where can you 'click')
- Not all elements are suitable for every project, it is good to know when enablers can be applied and when enablers are suitable or not suitable for the project

4. Check

- 'There is not much to hold on to in this step'. It fits in with the Deming circle (plan-do-check-act) and it is a good step further.
- Add a "who" and "how" to make it more explicit
- The approach to the step is good, by looking at what is going well instead of what is not
- Plan a 'check moment' in the project planning: For lazy project managers, a reminder is necessary to check things like this again. The practical "put a check in the planning after 6 months" for example to automatically run into the moment when it is there.

Tool

- Very clearly structured
- Accessibility of the tool in the online environment of Arcadis should be considered
- The next step could be to set up the operationalized 'flexibility enablers' of the tool in a modular way. Then you can choose the modules and use them right away, which saves time and effort.
- Can be used as kick-off intern and with client
- When this is meant for usage together with the client, this should be included in the information on the tool (introduction), 'this tool is also intended to start a conversation with the client'.
- Every PM is different and they all use the same tools, the difficulty is in the application
- Looking purely at flexibility and knowing when I should pay serious attention to this and knowing that information and tools are available for that is still a real challenge.
- Everything that gets attention grows