DO WE GET WHAT WE WANT?

ON STAKEHOLDER MANAGEMENT RELATED TO THE VERIFICATION AND VALIDATION PROCESS IN LARGE INFRASTRUCTURE PROJECTS

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Preface

You have just started to read my thesis ‘Do we get what we want?’. In this thesis, I describe how SM can help the client and contractor to perform the V&V process during the design phase of Dutch LIP’s. This thesis is written as part of my graduation for the master Construction Management and Engineering at the TU Delft and was commissioned by the company HOCHTIEF.

During a previous internship, I was with a contractor who had to deal with a UAV-gc contract for the first time and therefore was looking for the correct way to verify and validate the construction works. I thought it was a very interesting challenge to help with that. During my master, I carried out a project in Chile where I was responsible for stakeholder management. Stakeholder management is a concept that is still unknown in Chile, while many projects are stopped prematurely due to public protest. The combination of my interests in people and civil engineering and my previous positive experiences made me decide to focus my graduation research on stakeholder management.

As the final piece of the master, it should of course be the biggest challenge of your study career and I can say that it has become. In addition to the complex subject, the COVID-19 virus has made things complicated for me. I thought it would be nice to finish my civil engineering study with a social research, but ironically it mainly became a social challenge. In these challenging times, I once again realize that together you are much stronger, and more importantly, it is much more fun than when you do it alone. I would therefore like to express my gratitude to a number of people who helped me during my graduation project.

To start with my graduation committee. Bauke, you often said during the progress meetings: "As a first supervisor I have a lot of contact with Geert", but I really had the feeling that you invested more time in me than most first supervisors do in their graduate students. This despite the challenging home situation you are in due to the COVID-19 virus. Although your many questions frustrated me more than once, I am sure it has made my thesis better. Thank you. Christine, the anecdotes you told me from practice have often brought me back on my feet. I am really looking forward to learn a lot more from you in the future. Marian, in addition to your other advice, you helped me a lot to structure my thesis. Wijnand, you always summarized the feedback in the meetings nicely into concrete applicable action points. Thanks to you all.

A life without friends is like New Year's Eve without fireworks, as this year once again proved that it is impossible. I am so grateful that you all are in my life. Bo, I’m so glad I met you. What a wonderful time we already had and there are many more adventures to come, I love you. Anna, while doing this qualitative research I got even more admiration for you than I already had. Thank you for your listening ear and advice. I look forward to seeing you, Arjan, and Mare a lot in Amsterdam! Wim, my big brother, how wonderful that I started my student life with you and ended it as well. And what a beautiful journey we have made in between. I learn a lot from you but enjoy our time together even more. Marieke, thank you for the help in writing my thesis. Herman and Ria, it is impossible to put into words how grateful I am with you. Without the support, encouragement, but most of all love that I receive from you, I would never have made it. I love you. How happy I am with such friends and family, you mean everything to me!

I wish you all a pleasant reading.

Geert Ridderinkhof,

Utrecht, 1 February 2021

Abstract

The increased complexity and changes in collaboration between involved actors in the realization of large infrastructure projects (LIP's) cause major challenges. One of these challenges entails meeting stakeholders' requirements through verification and validation (V&V) during the design phase. Coordinating the design with the stakeholders can easily lead to delays or bad relationships. The V&V process originates from systems engineering (SE) and it seems that an attempt is being made to reduce the complexity by performing the V&V process in a systematic way. However, various researchers indicate that there is a need for interaction and it is doubted if this need for interaction is taken into account in this SE approach. The V&V process half-heartedly relates to stakeholder management (SM) while they seem to be a good fit. It is expected that a successful performance of SM can fill this need for interaction in the complex environment of LIP's. Therefore, this research sought an answer to the question:

> ***How can stakeholder management help to improve the verification and validation of the stakeholders' requirements during the design phase of large infrastructure projects in the Netherlands?***

Through a literature study into SM, an evaluation tool is formulated consisting of four core values. These values are: *setting goals together, assessing stakeholders, involving stakeholders in the decision-making,* and *continuously interacting with stakeholders*. A case-study approach is used to allow a deeper understanding of the application of SM in relation to the V&V process during the design phase in practice. Through semi-structured interviews, based on the evaluation tool, the perspectives of contractors, clients, and stakeholders on SM in relation to the V&V process were investigated. Conclusively, the findings from the three cases were compared based on different themes to gain an understanding of the role SM plays in relation to the V&V process.

Setting goals together, appears to be truly important in relation to the V&V process. Respondents believe that by setting goals together, parties involved become more aware of the underlying interests and concerns behind the requirements of the project and thus get a better picture of the purpose of the requirements. Consequently, it brings parties closer together from the start. Furthermore, *continuously interacting with stakeholders* during the process in an open way is important as this creates support among stakeholders. Through this, the contractor must discuss the progress of the design by reflecting on the overall picture and not only on the problems that arise. The stakeholders, but the client as well, find it very meaningful to be thoroughly informed about the reasoning behind the design choices of the contractor. This applies to *involving stakeholders in the decision-making* as well. The current way in which the stakeholders and the client actually participate in making decisions seems sufficient on condition that stakeholders and client are sufficiently informed about the motives of the contractor. In the context of the studied cases, *assessing stakeholders* does not appear to be important in the V&V process of the design phase. This research has not identified a clear correlation between the performance of the V&V process and a contractor or a client who is carrying out the SM related to the V&V process, the degree of collaboration seems much more important. Both the contractor and the client have substantial resources that are required to coordinate the design with the stakeholders and they have a common interest in monitoring the contract. Therefore, it is the interest of both of them to enter into good collaboration in managing the stakeholders in relation to the V&V process.

The ambiguity of the V&V process is recognized in practice as well, where the contractor and client struggle to find a more SE-driven approach or a more SM-driven approach. The context in which the process takes place determines which approach is more effective.

There are several directions for further research. First of all, this research uses an evaluation tool based on research into SM focusing on LIP's in general. Therefore, this research can be seen as an exploratory study into SM specifically aimed at the V&V process. It is recommended to conduct follow-up research

into further testing and specifying the evaluation tool. Furthermore, this research shows that there is a tension in the V&V process regarding monitoring the contract. Further research into contract management in relation to the V&V process is recommended as well.

Based on the evaluation tool, this research has made recommendations for determining an SM strategy in relation to the V&V process. Since every V&V process takes place in a different context, no unambiguous advice can be given. However, this research has shown that *setting goals together* and *continuously interacting with stakeholders* are both very important for the performance of the V&V process, regardless of the conditions of the process.

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ABBREVIATIONS

CRS	Customer Requirements Specification
CSF	Critical success factor
LIP	Large infrastructure project
RWS	Rijkswaterstaat
SE	Systems engineering
SM	Stakeholder management
SMART	Specific, Measurable, Attainable, Relevant and Time-bound
V&V	Verification and validation

1 Introduction

1.1 Construction process challenges of large infrastructure projects

Dutch infrastructure projects have become larger and more complex in the last years. It is expected that the Netherlands will face major infrastructure challenges in the coming decades as well (Hertogh & Westerveld, 2010; Groot, Saitua, & Visser, 2016). Ruijter (2019), who was project director at project Schiphol-Amsterdam-Almere and will be project director at project Zuidasdok, mentions in his thesis that in addition to the actual construction of large infrastructure projects (LIP's), more and more non-technical factors have come into play and social involvement in these types of projects has increased. At the same time, the form of collaboration between clients and contractors in the Dutch infrastructure sector has changed. The construction sector is on the move. Public clients either choose to outsource more activities, or decide to take a bigger role themselves when it comes to realizing LIP's (Ruijter, 2019). The increased complexity and changes in collaboration between involved actors cause major challenges in the realization of LIP's, resulting in project delay and cost overrun. One of these challenges entails meeting stakeholders' requirements through verification and validation (V&V).

HOCHTIEF has been working on LIP's for several years and are faced with this increasing complexity and major challenges. The company is contracted, as part of the ZuidPlus consortium, to realize the Zuidasdok project. Within this project, they particularly face challenges to verify and validate stakeholders' requirements throughout the project. Before the contract was awarded to ZuidPlus, the client investigated the wishes from the stakeholders and formulated these into contract requirements. In order to validate that the translation to the contract requirements has been done correctly, the client signed a management agreement ('Bestuursovereenkomst' in Dutch) together with the stakeholders. Thereafter, the client awarded the project to ZuidPlus. During the design phase, ZuidPlus had to verify and validate the design. Therefore, it must be checked whether the expectations of the stakeholders are met, which requires good coordination with them through the process. Although the contractor could propose involving a stakeholder in the design process, contact with the stakeholders took place through the client. As a result, the contractor had little insight into the views of the stakeholders with regard to the design. The coordination with the stakeholders became a laborious process in which there was not only substantive disagreement about the design, but the stakeholders also expressed their dissatisfaction with how they had been involved in the process. Several stakeholders reported that they were insufficiently involved.

An example of the problems that arose concerning the coordination with stakeholders in the Zuidasdok project, was a discussion about a vertical point of ascent. This vertical point of ascent includes an elevator, escalators and regular stairs and is located between two metro tracks. Various stakeholders set requirements for these components. However, during the design phase, the contractor discovered that these requirements were in conflict with each other and thus it became impossible to perform the verification. With that discovery they went to the client, after which the client entered into conversations with the various stakeholders. This discussion went back and forth between the contractor who worked on the design and the client who took care of the contact with the stakeholders. It was unclear for a long period of time how the design could meet the stakeholders' requirements. As a result, it took a number of years to reach a validated design.

The Zuidasdok project is not the only project that encountered problems in verifying and validating stakeholders' requirements. In the MaVa A15 project, the client and contractor had difficulties in aligning the design with the stakeholders. Part of the MaVa A15 project was the construction of the Botlekbrug. In order to meet a contract requirement, the foundation of the bridge had to be built at a specific location. However, this contradicted another requirement that stated that it was not allowed to construct in or near a pipeline corridor. After the client and contractor failed to solve this challenge themselves, they had to involve the relevant stakeholders to reach a consensus. After all, a consensus with the stakeholders

was reached after two years of negotiation. As a result, the V&V process took much longer than anticipated at the beginning of the project.

These examples make it clear that the client and contractor have difficulty involving stakeholders in LIP's in such a way that their V&V process runs smoothly. The client and contractor will have to find a way to properly involve stakeholders in the process so that stakeholders' satisfaction is increased and long and costly discussions are avoided.

1.2 Large infrastructure projects

Although there is no clear definition for LIP's, multiple researchers describe these projects in a similar way. Hertogh (2008, p. 16) defines LIP's as "*projects which have to be developed to meet rising and changing demands for interregional and international mobility"*. As Locatelli, Invernizzi and Brookes (2017) explain, LIP's are megaprojects in the transportation sector. Van Marrewijk et al. (2008, p.591) defines megaprojects as "*multibillion-dollar mega-infrastructure projects, usually commissioned by governments and delivered by private enterprise; and characterized as uncertain, complex, politically-sensitive and involving a large number of partners"*. The latter emphasizes the organizational complexity that comes with the presence of multiple private firms in connection with the political stakeholders of a project (Locatelli, Invernizzi, & Brookes, 2017).

Flyvbjerg, a well-known scientist in this research field, defines LIP's as *"the most-expensive infrastructure projects that are built in the world today, typically at costs per project from around a hundred million to several billion dollars"* (Flyvbjerg, 2007). Furthermore, he describes the characteristics of LIP's as:

- *Multi-actor processes.* LIP's are projects conducted in an environment with a lot of stakeholders, where it is inevitable to avoid conflicting interests.
- *Complex interfaces.* Complexity always has been present in LIPs, complexity can be technical-, social- or can have another character.
- *Long planning horizons.* The life cycle of a LIP can be up to 50 years.
- *Scope changes.* These are changes in the project boundaries due to changing demands or issues.
- *Incorrect allocating of profits and risks.* Risk and responsibility divisions are often underestimated or misinterpreted, which leads to issues in the collaboration.
- *Unusual or new technologies.* Unknown or new technologies can cause issues for contractors.

According to Mok, Shen and Yang (2014), the huge size and high complexity of mega projects result in about three major challenges in their project management:

1. The involvement of many different stakeholders creates complex relationships and conflicting interests.
2. High project uncertainty.
3. Their governance by both public and private organizations leading to high public attention and controversies.

Sun and Zhang (2011), are defining mega construction projects as *"massive investments of infrastructure, often initiated by the government, which have a long schedule, huge lifespan, extreme complexity and significant social impacts".* From the previously described definitions, it can be concluded that multiple researcher recognize the high level of complexity of LIP's on different levels.

1.3 Understanding the V&V process in Dutch LIP's

1.3.1 Dutch LIP's in general

Dutch LIPs are initiated by the government and executed by agencies for Dutch governmental infrastructure projects, like RWS and ProRail. Government authorities like RWS, provinces or municipalities often formulate ambitions for an area to which private companies respond with a solution. A tender procedure determines which contractor is awarded with the contract to execute the LIP together with a public authority (Rijksoverheid, 2015).

From project initiation to project delivery, the client and contractor are concerned with validating and verifying the design with stakeholders' requirements. In the Netherlands, the V&V process of infrastructural projects is rooted in Systems Engineering (SE). A collaboration between clients and contractors combined their vision on the V&V process in the SE Guideline, drawn up for the Dutch civil engineering sector. Appendix A specifies how the SE Guideline describes the V&V process.

The SE Guideline has been by a collaboration between clients and contractors (Rijkswaterstaat, ProRail and various branch organizations). SE is used at complex systems, where the system is divided (decomposed) into smaller, easier to handle pieces.

1.3.2 Defining the V&V process

First, it is necessary to provide definitions of the V&V process. In literature the V&V process is defined in many different ways. In this way, it can be determined what does and what does not fall within the scope of this research. In this research we are interested in the V&V process of requirements coming from stakeholders. The definitions of the V&V process which are used for this research are:

Verification	The confirmation by objective evidence that the specified requirements have been met.
Validation	The confirmation by checking whether the product[1] is in line with the intended use of the stakeholders.
V&V process	All activities associated with verifying and validating the product.

To clarify these definitions, we use the Zuidasdok project example as mentioned in section 1.1. In this project a vertical point of ascent had to be designed. Stakeholders set requirements for the dimensions of the elevators, escalators and regular stairs. During the design phase, the contractor discovered that the requirements were conflicting and therefore could not verify the design. It may also happen that a design can be verified but not validated. Suppose that the requirements were not conflicting so the contractor could verify the design. However, the verified design did not meet the capacity demand as set by the stakeholders. This means the design would be verified but not validated.

1.3.3 The V&V process steps

In order to discover the steps that the client and contractor go through to verify and validate the requirements of the stakeholders, standard procedures for the V&V process were investigated. As the client of many Dutch LIP's, Rijkswaterstaat is an important party that prescribes V&V procedures. Therefore, documents drafted by Rijkswaterstaat were examined in this research. Furthermore, project reports from contractors of several LIP's were analysed to gain an understanding of the practical implementation of these procedures in the design phase. Subsequently, the correctness was checked by means of interviews with experts in the field from both the client and contractor side. The content of this section is therefore based on empirical research.

[1] In this research, the V&V process of the design phase is investigated and therefore the 'product' refers to the design. For the scope of this research, see section 2.3.

In this research, a distinction is made between a number of phases of the project. These are shown in Figure 1.

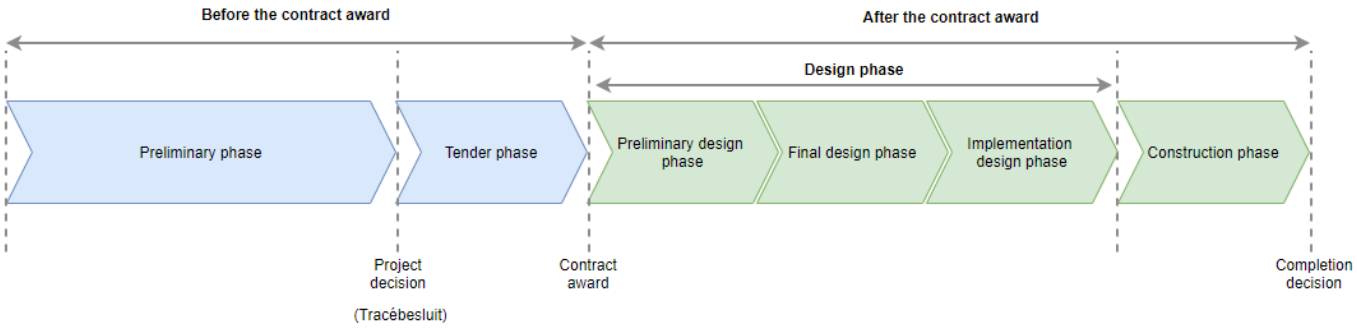


Figure 1: Phases of the project

1.3.3.1 Before the contract award

Before the contract is awarded to a contractor, the client starts with investigating the ambitions and challenges in the area and begins with their V&V process. After the contract is awarded, the contractor comes into play and becomes responsible for the V&V process. During the design phase, the contractor therefore continues with the process set up by the client. Although this research focuses on the V&V process during the design phase, see section 2.3, it is still important to know what steps the client has already carried out. For this reason, Appendix B describes how RWS is performing their V&V process in the preliminary phase of LIP's.

1.3.3.2 After the contract award

After the contract is awarded, the design phase starts. In this phase, the contractor will draft the design based on the contract requirements. In general, it is the contractors responsibility to design and realize a demonstrable, safe and working system for the end-users, with proper coordination of stakeholders (van Tol & Roeleveld, Verificatie- & Validatiemanagementplan, 2018). In every project, alignment takes place between client and contractor to verify and validate the requirements. However, the way this is done differs per LIP. The client coordinates the requirements with the stakeholders in the preliminary phase. During this phase, the client has already come to a certain level of agreement with the stakeholders. After the contract award, the contractor further specifies the project. The client either chooses to continue stakeholder alignment during the design phase, as a way of preventing large deviations from earlier agreements. In other cases, the client decides to place the responsibility of coordinating the design with the stakeholders to the contractor[2].

In order to get an impression of how a contractor carries out the V&V process, project documents of the Zuidasdok project have been examined, from which Figure 2 is generalized. The correctness of Figure 2 was validated through interviews with several experienced process managers who worked on V&V plans in various LIP's [3][4].

[2] Davidse, C. (2020, June 26). Process flow of the V&V of stakeholders' requirements. (G. Ridderinkhof, Interviewer)
[3] Nillesen, T. (2020, June 19). Process flow of the V&V of stakeholders' requirements. (G. Ridderinkhof, Interviewer)
[4] Van Tol, W. (2020, May 26). Process flow of the V&V of stakeholders' requirements. (G. Ridderinkhof, Interviewer)

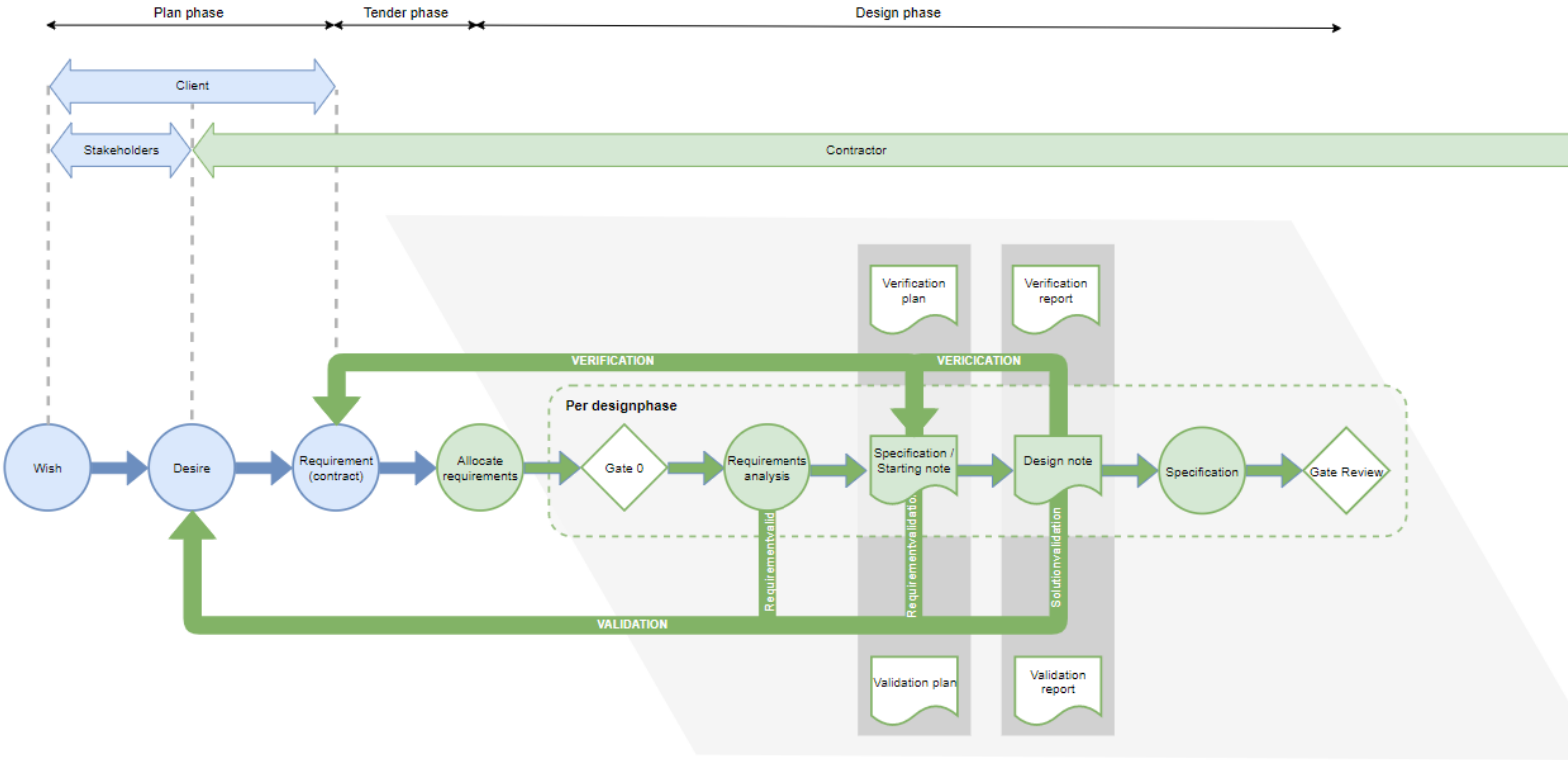


Figure 2: An average V&V plan of a contractor

The V&V process for a contractor starts right after the contract is awarded. The requirements of the contract are input for this process, so the contractor continues with the process which is performed by the client. Some experienced process managers on the client side and contractor side indicate that the contractor is often not fully informed of the previously performed Customer Requirements Specification (CRS)[54]. Usually, the contract requirements are first analyzed by the contractor in a requirement analysis, after which their findings will be discussed with the client and/or stakeholders. In some cases, it is internally examined whether requirements can be interpreted in different ways and it is then checked with either the client or the stakeholder if the interpretation is right. However, the experienced process managers indicate that it differs per project whether and how the requirements analysis is carried out[634].

After this step or simultaneously, the contractor starts designing. Designing is performed in multiple phases, in which the design is further specified in each phase. Usually, the contractor starts each phase with a gate review in order to check whether the project team is aligned, whereby the client is often invited in terms of transparency. Normally, each design phase exists of a starting note (‘Start Notitie’ in Dutch) and a design nota (‘Ontwerp Nota’ in Dutch). Together with the start note, the contractor presents the V&V plan for that design phase to the client. As part of the V&V plan, the contractor discusses which stakeholders they intend to involve and how frequent this will be. When the design is further detailed in the design note, this is presented to the client together with the V&V report, whereby the client gets informed about the completed V&V steps of the contractor.

At the end of each design phase, an internal and external gate review takes place. This determines whether all planned activities have been carried out, if products are of sufficient quality and if risks have been mitigated sufficiently. If the gate review is successful, the design note will officially be submitted to the client and the next design phase starts.

[5] Den Haan, R. (2020, June 23). Process flow of the V&V of stakeholders’ requirements. (G. Ridderinkhof, Interviewer)

1.4 Different perspectives on the V&V process

Although contractors do describe their V&V plan in their project management plan (as part of the quality system), they do not carry out the V&V process according to a standard procedure. Every project is therefore re-examined to find the most convenient way to demonstrate that their design meets the requirements of the contract. Davidse (2020) indicates that opinions about executing a V&V plan within a contractor usually differ, whereby on the one hand people find it a lot of hassle to set up and execute a V&V plan and on the other hand people say that it ensures a structured way of working[2]. The reason that a contractor draws up and executes a V&V plan is probably mainly to keep the client satisfied. According to van Dam (2020), it usually happens in the construction world that the plans of previous projects are applied to a new project. In this way, he says, a plan is applied and improved several times and lessons are learned from previous projects[6]. On the other hand, because there are no standard procedures, a lot of work is repeated several times in this way.

Project success is a universally debated subject for its definition. Literature seems to agree on one thing: whether the project is considered a success depends on the perspectives taken to judge it (Koops, Coman, Bosch-Rekveldt, Hertogh, & Bakker, 2015). In this sense, the awareness of the perspectives of the different parties involved in the V&V process is important as well. These are discussed in this section.

1.4.1 The client

The client aims to make project risks manageable and to create support for the project among the stakeholders. Through this, the client hopes to minimize surprises in planning and costs[5]. RWS, as the biggest LIP-client in the Netherlands, measures project success according to which extent stakeholder requirements are being met (Rijkswaterstaat, 2019).

The client wants to make use of the creativity of the market regarding the interpretation of the requirements. To make that happen, the client specifies the requirements in a functional manner only. This enables the contractor to choose the most optimal design and to propose solutions (Stuurgroep 4P Systems Engineering, 2009). During the preliminary phase, the client collects the wishes of the stakeholders and formulates them into functional requirements. In some cases, the client does not include the original wishes of the stakeholders to the contract and thereby deliberately withholds information[5]. As a result, the interest in creating support among the stakeholders may conflict with the interest in using the creativity of the market.

1.4.2 The contractor

The contractor aims to get “a demonstrable, safe and working system for the end-users, with proper coordination of stakeholders and additional contractors” through the V&V process (van Tol & Roeleveld, Verificatie- & Validatiemanagementplan, 2018).

Demonstrability consists of the following two aspects:

1. to arrive at the objective proof of the correct implementation of requirements in process, design and built product.
2. to arrive at a process or product expected from stakeholders that is predictable and structurally established and that, in accordance with agreements, meets the correct intended use.

Furthermore, the contractor has the ambition to meet a requirement at the lowest possible cost in order to earn as much money as possible. Because of this motivation, a contractor desires to limit the duration of the design phase and starts with the actual construction of a project as soon as possible. This creates the incentive to conduct the V&V process as quickly as possible. Thence, they sometimes see the many paperwork of the V&V process as a disadvantage (Stuurgroep 4P Systems Engineering, 2009).

[6] Van Dam, J. (2020, June 16). Process flow of the V&V of stakeholders’ requirements. (G. Ridderinkhof, Interviewer)

1.4.3 Stakeholders

From the project stakeholders' point of view, a project is an opportunity to influence the end-result for their own objective, goal or mission as an individual or as an organization. Stakeholders can apply strategies to try to affect the decision-making process in such a way that it matches their specific objectives, in order to satisfy their individual vested interest (Mok, Shen, & Yang, 2014).

1.5 The ambiguity of the V&V process

The SE Guideline aims to support in which technology, standardization and tools play an important role in the search for performance improvement. But it is also seen that this improvement can be sought in process improvement and there is recognition for the fact that attention to attitude and behaviour (soft skills) is important in the further application of SE tools (ProRail, Rijkswaterstaat, Bouwend Nederland, NL ingenieurs, de Vereniging van Waterbouwers, Uneto-VNI, 2013). A study that has researched project experiences about the V&V process draws similar conclusions (Stuurgroep 4P Systems Engineering, 2009). Within this study, the experiences of clients and contractors were investigated by means of interviews. They conclude that the V&V process can stimulate systematic and clear way of working. But on the other hand, the many paperwork from the process is seen as a disadvantage. The study highlights that sharing a common project goal amongst all involved actors proves to be a critical success factor for the project. However, this entails an actor attitude that cannot be set down in requirements. As is often argued in management literature, here too the 'soft side' turns out to be a very hard prerequisite for success. No matter how much paper is involved, a successful V&V process is a matter of good communication with the parties involved (Stuurgroep 4P Systems Engineering, 2009).

Although the V&V process of LIP's can be clearly described and might be systematically followed, it appears from section 1.1 that the coordination with the stakeholders does not run smoothly. The coordination of the design is an interaction between the client, the contractor, and the stakeholders, whereby the client and contractor have to involve the stakeholders in the process. But, stakeholders express their dissatisfaction with the extent to which this is happening.

Ruijter (2019), sees two sides of the spectrum on the method of collaboration between client and contractor at LIP's to deal with issues such as complexity and ambiguity described in literature. In part of the research field, the focus on collaboration is mainly system-oriented, trying to reduce complexity based on the contract, standard procedures, and control. This description seems to correspond with the way in which the client and contractor intend to perform the V&V process. The other part of literature describes a process-oriented collaboration, where complexity is embraced to make it manageable. Sundaramurthy and Lewis (2003), scientists in this field of research, suggest that parties should look for a balance between those two approaches, in which parties develop an adaptive capacity to reflect on and increasingly learn to deal with unexpected events.

Van der Voort, Koppenjan, ten Heuvelhof, Leijten, and Veeneman (2011) are describing something similar in their paper about competing values in innovative projects. They describe two types of approaches to project management, a predict-and-control approach and a prepare-and-adapt approach. The predict-and-control approach is focussing on controllability. Where tools are aimed at predicting the design through system engineering and project management adds instruments to ensure that the predicted outcome is actually the real outcome. However, these tools do not typically provide room for flexibility in a project with a complex character. The prepare-and-adapt approach focusses more on flexibility, learning and trust. Where the project team needs to prepare for surprises by committing everyone involved to deal with them and adapt to these surprises. Since projects have characteristics that demand controllability and characteristics that demand flexibility, the reality of managing projects is always finding a mix between the two approaches (van der Voort, Koppenjan, ten Heuvelhof, Leijten, & Veeneman, 2011).

The above describes an ambiguity where one approach does not rule out the other. According to Hertogh and Westerveld (2010), the various characteristics of LIP's asks for interaction. While

stakeholders are crucial in the development of LIP's, it appears that this need for interaction is not taken into account in the approaches of systems management which focus on control. Strategies based on interaction, on the other hand, focus on satisfying needs through interaction in the network of stakeholders (Hertogh & Westerveld, 2010). Therefore, it is expected that a successful performance of stakeholder management (SM) can fill this need for interaction in the complex environment of LIP's. Proper implementation of SM will, among other things, increase awareness of each other's interests while working on the project goal. But, despite the contribution of previous studies in proposing practical SM-methods, putting stakeholder philosophy into project management practice remains a major challenge in present-day stakeholder research (Mok, Shen, & Yang, 2014). Practical approaches to SM are developed in a way that is difficult to follow by contractors (Agle, et al., 2008). Therefore, this research aims to find guidelines to perform SM during the V&V process in order to ensure smooth coordination of the design with stakeholders.

1.6 Summary

Managing LIP's has become more complex, both on a technical and organizational level. It turns out that this has made it more challenging to verify and validate stakeholders' requirements. Problems seem to arise in the step from design requirement to design choice, coordinating the design with the stakeholders can easily lead to delays or bad relationships. The contractor and client are unable to involve the stakeholders in the design phase in such a way that the V&V process runs smoothly. Stakeholders often indicate that they are insufficiently involved in the V&V process and do not approve the design.

The interests between the parties involved appear to differ and might conflict with each other. For example, the contractor has the obligation to meet the requirements of the contract but is given the freedom of the client to give its own interpretation within the solution space. Thereby, the client hopes to use the creativity of the market, but this also gives the contractor the freedom to implement a requirement as cheaply as possible. The creativity of the market is therefore used, but this might not be the way the client intended and it can often happen that the stakeholder wants a different interpretation of the requirement, which may be more expensive. There are more interests between the client, contractor and stakeholders that may conflict with each other. It is questioned whether these different interests are properly brought to the table during the process and whether they are dealt with correctly.

Despite the fact that there are procedures for the V&V process, each project seeks its own way of going through the process. There seems to be ambiguity in the V&V process, the process can be approached in various ways. The V&V process originates from SE and it seems that the client and contractor are trying to reduce the complexity by performing the V&V process in a systematic way. Besides, various researchers indicate that there is a need for interaction when carrying out LIP's and it is doubted if this need for interaction is taken into account in this SE approach. Is there enough attention for SM when carrying out the V&V process?

2 Research design

2.1 Problem statement

The increase in scope, complexity and social involvement of Dutch LIP's is an observed trend that is likely to continue (Hertogh & Westerveld, 2010; Groot, Saitua, & Visser, 2016; Ruijter, 2019). These developments have increased the number and complexity of collaborations between the parties involved (Pitsis, Sankaran, Gudergan, & Clegg, 2014). An important aspect here is both the interests as perception of interests of organizations and people differ and may vary over time. At the same time, the form of collaboration between clients and contractors in the Dutch infrastructure sector has changed (Ruijter, 2019). As a result, coordinating the design with the stakeholders easily lead to delays or bad relationships. The contractor and client are unable to involve the stakeholders in the design phase in such a way that the V&V process runs smoothly. Stakeholders often indicate that they are insufficiently involved in the V&V process and do not approve the design. It is doubted whether the need for interaction is taken into account in the V&V process. The problem statement of this research is therefore:

> ***The verification and validation process half-heartedly relates to stakeholder management while they seem to be a good fit.***

2.2 Research objective

Clients and contractors search for a way to involve stakeholders in the V&V process so that the coordination with stakeholders will run smoothly. Section 1.3.3 shows that the V&V process followed by the client and contractor is based on SE principles. While the various characteristics of LIP's ask for interaction, it appears that this need for interaction is not taken into account in the approaches of systems management which focus on control (Hertogh & Westerveld, 2010). It is expected that SM principles can fill this need for interaction and provide a helping hand in the execution of the V&V process. Proper implementation of SM will, among other things, increase awareness of each other's interests in the V&V process.

This research looks for ways in which SM can help the client and contractor to improve the coordination of the design with stakeholders. It must help the client and contractor to choose the right strategy in particular situations in the V&V process, depending on the context where its performed. By using these strategies through the V&V process, it minimizes budget overruns and project delays, and it helps to create healthy relationships between parties involved. Making the research objective:

> ***This research aims to find how stakeholder management can help the verification and validation process in order to ensure a coordination with stakeholders that proceeds quickly and in good relationship.***

2.3 Research scope

The scope of this research is the V&V process of the stakeholders' requirements during the design phase of LIP's in the Netherlands. The core content of this thesis is formed by a literature study and case studies. The literature and cases are placed within the following boundaries:

- The context of SM is specific to the national or regional environment of the project *(Mok, Shen, & Yang, 2014)*, therefore it is important to know what the geographical boundaries are of this research. In this research, the Dutch borders are seen as the geographical boundaries.
- The report is conducted as a graduation research from the master Construction Management and Engineering, within this research only LIP's will be investigated.
- The focus of this research is limited to Dutch LIP's with integrated contracts.
- This research focuses on the V&V process during the design phase of LIP's. This phase starts immediately after the contract is awarded to the contractor. In this phase, there is an area of tension in which the contractor joins the project as a new party and the demarcation of

responsibilities between the client and contractor are not always clear. The design phase usually consists of three different phases, namely: the preliminary design phase, the final design phase and the implementation design phase. To collect the right data, the interview questions therefore concern those phases of the project.

- Different perspectives on the V&V process are considered in the case studies: the contractor's perspective, the client's perspective, and the stakeholders' perspective.
- This research considers stakeholders in relation to the V&V process of the design phase, these are stakeholders who have a contractual connection to the project. One can think of operators of current or future project assets.

2.4 Research questions

2.4.1 Main research question

In order to reach the objective of the research, the main research question was derived. This main research question is divided into sub-questions which all contribute to answering the main question. The main research question is formulated as follows:

How can stakeholder management help to improve the verification and validation of the stakeholders' requirements during the design phase of Dutch large infrastructure projects?

2.4.2 Sub-questions

The main research question is dissected into four sub-questions, these are presented in this section.

1. *What are critical factors to perform successful stakeholder management and how can these be recognized in practice?*

First, an investigation is needed into the critical success factors (CSF's) of SM. CSF's are seen as those activities and practices that should be addressed in order to ensure effective management of stakeholders (Yang J. , Shen, Ho, Drew, & Chan, 2009). The answer to this sub-question will be used as a starting point for further research.

2. *How is SM currently conducted in relation to the V&V process in the design phase?*

Research is conducted on how stakeholders are currently involved in the design phase of LIP's in relation to the V&V process. Based on the results of sub-question 1, there is evaluated to which extent projects currently meet the CSF's of SM.

3. *How does SM affect the V&V process in the design phase?*

After evaluating how much SM is performed in relation to the V&V process, it is researched how SM affect the V&V process in the design phase. This is done by analyzing various themes in order to discuss its effects on the V&V process and thereby determining how SM can help the V&V process.

The purpose of this master thesis is to improve the current situation of the V&V of the stakeholders' requirements during the design process of LIP's. Throughout answering the previous research questions, conclusions can be drawn about how SM can help in carrying out the V&V process. These findings are used to formulate the scientific and practical recommendations for SM that will help both the client and contractor to facilitate the V&V process. By applying this in future projects, it minimizes budget overruns and project delays, and it helps to create healthy relationships between parties involved.

2.5 Methodology

In the following sections, it is explained how the research questions will be answered. The research is divided into different parts, each contributing to answering the main research question. For each part, it is described how the content is planned to be derived.

2.5.1 Literature study

As introduced in the preliminary study into the current application of the V&V process in Dutch LIP's, SM could offer help in the V&V process during the design phase. Therefore, the second part of the background study is a literature review on the CSF's of SM. A literature review is considered useful to gain in-depth knowledge of a research topic. Scholars from the TU Delft with experience and in-depth knowledge in the research field are connected to this research and have supported by selecting applicable scientific papers. Part of this literature study is to investigate how the CSF's can be implemented. Thereby, this literature study will answer *sub-question 1*. The output of the background study is a theoretical framework which serves as input for the case studies.

2.5.2 Case studies

Case studies are performed to derive an answer to *sub-question 2.* Two LIP's are selected, where the LIP's differ in the way in which the coordination of the design with the stakeholders is done. In one LIP, the coordination of the design with the stakeholders is done by the client and in the other LIP this task is more in the hands of the contractor. This concerns the two following LIP's:

- ***Zuidasdok**, in this project the coordination of the design with the stakeholders is done by the client.*
- ***ViA15**, in this project the coordination of the design with the stakeholders is done by the contractor.*

Within these large projects, sub-projects are selected to function as research cases. More detail on the case selection can be found in section 4.2. For these cases, there is examined whether and how SM is included and how this affected the satisfaction about the V&V process. This is done by using the observed CSF's of SM. The cases are investigated using project documents of the specific case and by conducting in-depth interviews with those involved in the V&V process.

The network of HOCHTIEF is used to contact the key players who were involved in the V&V process of the cases. Within these cases, the perception of contractors, the client, and the stakeholders on the V&V process is investigated. The interview approach used in this research is semi-structured. This gives the flexibility needed in an interview to anticipate to the answers of the respondents while remaining in a structured form of pre-set questions that are formulated after completing the literature study. Respondents are asked to evaluate the V&V process and, based on the literature study into SM, it is then questioned how stakeholders are involved in the process. A semi-structured interview provides a level of detail needed to answer the sub-questions as their outcome is largely based on experience. The disadvantage is the possibility of the respondent being biased (Adams, 2015), that is why interviews are held with various parties.

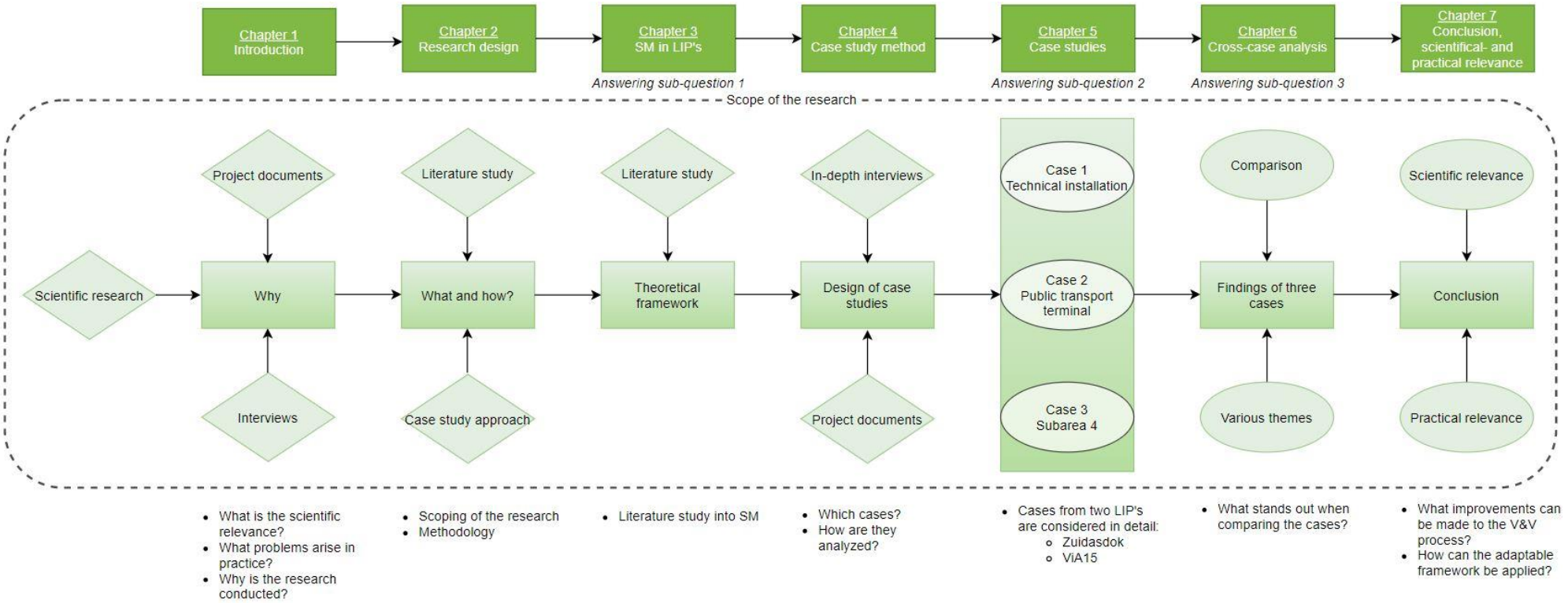
2.5.3 Cross-case analysis

To understand the role which SM can play in relation to the V&V process, *sub-question 3*, the three cases are compared with each other based on different themes. Furthermore, the results of the case studies, together with the context in which they were found, are presented and possible patterns are recognized.

2.5.4 Stakeholder management

The research is conducted in collaboration with the Delft University of Technology (TU Delft) and the contractor HOCHTIEF. With me included, this results in three stakeholders of the research. To take into account the wishes and requirements of all parties involved, contact will be maintained on a weekly basis between me, my supervisor from HOCHTIEF and my first supervisor from TU Delft (as a representative of the TU Delft). A kick-off meeting, two mid-term meetings and a green light meeting are V&V moments that must ensure a good end result of this research. Resources of both the TU Delft and HOCHTIEF will be used to gather information about specific subjects.

2.6 Thesis outline



3 Stakeholder management in large infrastructure projects

The research aims to find how SM can help the V&V process to be executed quickly and in good relationship. Therefore, this chapter presents a literature study into SM. Various top journals (like Construction Management and Economics, International Journal of Project Management, Journal of Civil Engineering and Management) and search engines (like Google Scholar, Elsevier and the repository of TU Delft) were investigated using the keywords 'stakeholders', 'stakeholder management', 'stakeholder management in large infrastructure projects', 'stakeholder management in construction projects', 'involving stakeholders in projects', 'essentials for stakeholder management', 'critical success factors of stakeholder management', and more. Using these search engines and keywords, the articles with the most hits and the most recent research were chosen. The first section provides an initial introduction of SM in LIP's. In section 3.2, we derive an understanding of the activities and practices that researchers describe as essential to successful management of stakeholders. Section 3.3 provides insight into the possible ways of giving practical interpretation of the factors of the evaluation tool. In conclusion, section 3.4 presents the evaluation tool to evaluate the performance of SM in relation to the V&V process.

3.1 Stakeholder management in general

The definition of stakeholders and SM differs among researchers. Freeman (1984, p.46) defines a stakeholder as an individual who can or is affected by the achievement of the organization's objectives. Another commonly used definition is that of Cleland (1985): stakeholders are those whom have a vested interest in the outcome of the project. Wesselink and Paul (2015) define a stakeholder as a person or organization that is affected (positively or negatively) or who can influence a specific organization, a government decision, a new product or project. In general, stakeholders are individuals or organizations that are either affected by or affect the development of the project (El-Gohary, Osman, & El-Diraby, 2006). This research considers stakeholders in relation to the V&V process. This limits stakeholders to involved parties who have a contractual connection to the project, as mentioned in the scope of this research.

Wesselink and Paul (2015) describe 'management' as a process in which the efforts/activities of the organization members are coordinated and directed towards the realization of the common goal. Then, SM is an organizational process that ensures that a company develops a relationship with its stakeholders that suits the interests of those stakeholders, the company and the business activity. SM thus focuses on the interests of all parties involved while keeping the common goal in mind. According to the PM body of knowledge (2013), SM includes the processes required to identify the stakeholders, to analyse their expectations and impact on the project and develop appropriate strategies to effectively engage and control stakeholders in project decisions and execution.

An increasing number of studies point out the importance of SM in construction projects (Newcombe, 2003; Olander & Landin, 2005; El-Gohary, Osman, & El-Diraby, 2006). However, the performance of SM in LIP's is criticized as unsatisfactory (Pryke & Smyth, 2006). Its process is "characterized by spontaneity and casual actions" (Karlsen, 2002). Converting an SM plan into concrete actions or strategies is rarely easy (Ward & Chapman, 2008). Furthermore, Ward and Chapman (2008) are indicating wrong SM to be the main source of uncertainty and complexity in the project environment.

3.2 The essentials for successful stakeholder management

This research is focused on the role of SM in relation to the V&V process. However, no research has been found on SM specifically in relation to the V&V process. Therefore, this literature study examines what researchers see as essential to improving SM. Later in the research, in the case studies, it is examined how these findings relate to the V&V process.

3.2.1 Several researchers on essentials for successful stakeholder management

Nowadays, the importance of engaging stakeholders in the decision-making process is universally recognized in order to improve the quality of the project and to decrease protests afterwards (Ignaccolo,

Inturri, Giuffrida, Le Pira, & Torrisi, 2017). Landin (2000) mentions the importance of stakeholder communication during the decision-making process as she states that “the long-term performance of any construction and its ability to satisfy stakeholders” depends on this. Besides stakeholder communication, Jergeas et al. (2000) identify “setting common goals, objectives and project priorities” as an essential activity that improves the performance of SM.

When conducting SM, it is vital to be aware of conflicting perspectives amongst stakeholders. Ignaccolo et al. (2017) state that it can be helpful to identify possible scenarios of stakeholder interaction in advance to plan effective participation processes. Recognizing and acknowledging each other’s viewpoints contributes to building robust relationships, thereby avoiding preconceived ideas and assumptions (Olander & Landin, 2005). In this process, stakeholders can apply strategies to affect the decision-making process aiming to satisfy their individual needs. First of all, it is important to be aware of these strategies that stakeholders might use. Furthermore, it is useful to understand these strategies in forecasting stakeholders’ likely behaviours (Mok, Shen, & Yang, 2014).

Through a comparative study of two railway projects in Sweden, Olander and Landin (2008), found that the SM process mainly depends upon the communication of benefits and negative consequences brought on by the construction project. Furthermore, they identified four other factors within the SM process that could influence the SM process, namely: “analysis of stakeholder concerns and needs; evaluations of alternative solutions; project organization; and media relations”.

3.2.2 Critical success factors of Yang et al. (2009)

So far, activities are discussed that are seen by various scholars as essential for a successful implementation of SM in LIP’s. Yang et al. (2009) show an extensive quantitative study into CSF’s for SM. The study describes CSF’s as “those activities and practices that should be addressed in order to ensure effective management of stakeholders” (Yang J. , Shen, Ho, Drew, & Chan, 2009). In their research, they have performed a literature review of previous studies on SM in eight top journals (Construction Management and Economics, Journal of Construction Engineering and Management, Engineering Construction and Architectural Management, Journal of Management in Engineering, International Journal of Project Management, Automation in Construction, Project Management Journal and Building Research and Information) and four search engines (Google Scholar, ABI database, EI CompendexWeb, and ISI web of knowledge) where the keywords of “stakeholder”, “project respondents”, or “project environment” are used. In this way, fifteen CSF’s for SM in construction projects were identified. These CSF’s were analysed by a questionnaire among 183 project managers in the construction field (from client organizations and contractors), confirming these fifteen factors being critical for SM in construction projects. These CSF’s were later referenced by many scientists and acknowledged by practitioners. The CSF’s are listed below and are ranked by importance (Yang J. , Shen, Ho, Drew, & Chan, 2009):

1. *Managing stakeholders with social responsibilities (economic, legal, environmental and ethical).*

Social responsibilities encompass the obligation to produce a product, sell them at a fair price and make a profit, the obligation to obey the law, the ethical expectations that society has of organizations at a given point in time and the rising environmental expectation. Project teams should manage stakeholders with social responsibilities by taking into account all social responsibilities to ensure the project objectives are realized.

2. *Exploring stakeholders’ needs and constraints to projects.*

Analysing the stakeholders’ needs and list the detailed issues of the stakeholders to the project. All stakeholders’ needs should be examined during the project in order to obtain a satisfactory and realistic solution to the problem.

3. *Communicating with and engaging stakeholders properly and frequently.*

In order to maintain support and commitment of the stakeholders, effective, regular and planned communication is necessary for project success.

4. *Understanding the area of stakeholders' interests.*

Due to the complex nature of LIP's, there are a lot of different stakeholders' interests. Understanding these interests will help to design a fit-for-purpose project.

5. *Identifying stakeholders properly.*

Most researchers point out the importance of the identification and classification of stakeholders at the beginning of the project and during the execution of the project.

6. *Keeping and promoting a good relationship.*

Healthy relationships between the project organization and the stakeholders are essential for successful delivery of projects and meeting stakeholders expectations.

7. *Analysing conflicts and coalitions among stakeholders.*

A project manager should be aware of the (possible) conflicts and coalitions among stakeholders stemming from diverse interests.

8. *Predicting the influence of stakeholders accurately*

As mentioned before in section 1.4.3, a project is an opportunity for stakeholders to influence the end-result for their own objective, goal or mission. Therefore, predicting the influence of a stakeholder is an important aspect of successful SM.

9. *Formulating appropriate strategies to manage stakeholders*

A strategy for SM is the attitude of how the project team treats different stakeholders. Project teams formulate different strategies in order to manage their stakeholders.

10. *Assessing attributes (power, urgency, and proximity) of stakeholders*

The power of a stakeholder is the capability to control resources, create dependencies and support the interests of some organizations over others. Urgency refers to the extent to which claims of stakeholders require immediate attention. Proximity refers to the level of involvement of a stakeholder in the project.

11. *Compromising conflicts among stakeholders effectively*

In order to come to a win-win solution, it is important for project managers to compromise conflicts to make decisions.

12. *Formulating a clear statement of project missions*

Having a clear mission for the project at different stages is widely considered to be vital for the effective management of stakeholders. As Jergeas et al. (2000) mentioned, setting common goals, objectives and project priorities is important for SM.

13. *Predicting stakeholders' reactions for implementing the strategies*

Besides formulating appropriate strategies to manage stakeholders, it is of importance to predict the response of stakeholders on these strategies. A project team should try to predict the behaviour when implementing a strategy.

14. *Analysing the change of stakeholders' influence and relationships during the project process*

An important aspect of LIP's is that the interests and also the perceptions of interests of organizations and people are different and can, on top of that, vary over time. Therefore, stakeholders and their influence change over time making it important to keep track of this change throughout the project.

15. Assessing stakeholders' behaviour

During the SM process, project teams should examine the capacity and willingness of stakeholders to threaten or cooperate with the project team, so they can prepare for responses.

After finding these fifteen CSF's, Yang et al. (2009) applied factor analysis to determine the underlying relationships and to categorize the CSF's into a fewer number of groupings. Five core values were identified, which they have put in a framework for successful SM in construction projects. This framework is shown in Figure 3.

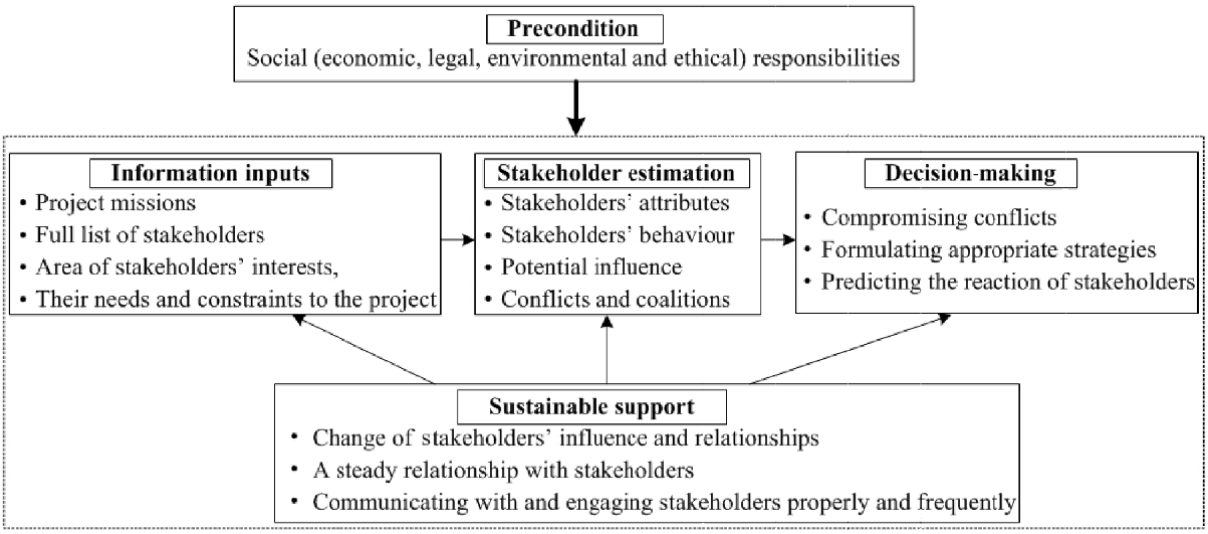


Figure 3: A framework for successful SM in construction projects (Yang J. , Shen, Ho, Drew, & Chan, 2009).

3.2.3 Wesselink and Paul (2015) on essentials for successful stakeholder management

The framework for successful SM of Yang et al. (2009) is the result of a research at an international level in the construction field, whereas Wesselink and Paul (2015) focus on Dutch projects. They have formulated an approach which is often used in Dutch LIP's to manage stakeholders called strategic environment management ('Strategisch Omgevingsmanagement (SOM)' in Dutch). This approach aims to prevent or resolve conflicts and lay the foundation for a sustainable dialogue and relationship with the environment. At its core, the SOM approach is a proactive intervention strategy based on sincere attention in the interests of the stakeholders. One that ensures an early dialogue through which the "pain" in terms of adjustments to plans is taken at the beginning of the process and does not lead to (substantial) exceeding of budgets and schedules at the last minute. The following elements are included in the SOM approach to ensure successful management of stakeholders (Wesselink & Paul, 2015):

1. Setting goals
2. Inventory of issues and stakeholders
3. Identifying and analysing positions and interests
4. Determining strategy per stakeholder
5. Start an effective and result-oriented dialogue
6. Negotiate constructively
7. Negotiate conflict resolution
8. Anchoring and monitoring agreements
9. Evaluate working method and adjust procedures

3.2.4 Combining the CSF's for successful stakeholder management

In order to evaluate the performance of SM in relation to the V&V process, an evaluation tool will provide structure and consistency. The evaluation tool will consist of core values that are filled by the factors

that the aforementioned researchers have identified as critical for successful SM. In this section, a first draft will be made of the evaluation tool, by combining the CSF's into various core values. The same definition for CSF's is used as Yang et al. (2009), which is: "those activities and practices that should be addressed in order to ensure effective management of stakeholders" (Yang J. , Shen, Ho, Drew, & Chan, 2009).

Looking at the previous sections, it can be concluded that various well-known researchers cite comparable essentials for the successful implementation of SM. The activities and practices described in section 3.2.1 are all reflected in both the fifteen CSF's by Yang et al. (2009) and in the essentials for successful SM according to Wesselink and Paul (2015). Also, when comparing the elements of the SOM approach with the CSF's of Yang et al. (2009), a lot of similarities are found. The first four elements of the SOM approach are clearly reflected in the CSF's of Yang et al. (2009). The fifth element of the SOM approach is about first (renewed) contact with the stakeholders and can be linked to the third CSF. Element six is about the interaction with stakeholders where deeper attention is paid to understand each other's interests, ideas and plans and asks for insight into which issues cause conflicting interests and why. This element can be linked to several CSF's, namely numbers two, three, seven, ten, and fourteen. The seventh element highlights the importance of conflict resolution, which is also stated in the eleventh CSF. Element eight and nine of the SOM approach elaborate on the monitoring and evaluation of the agreements made with stakeholders. These elements are difficult to link to a specific CSF but can be attributed to the core value 'Sustainable support'.

The research of Yang et al. (2009) is chosen to be used as a basis for the evaluation tool for three reasons. First of all, because this extensive literature research is published by world prominent journals, confirmed by project managers from both the client and contractor side and the research is supported by other well-known researchers in the field of SM. Therefore, it gives a large degree of reliability. Secondly, because Yang et al. (2009) already performed a factor analysis and thereby identified four core values that can be used to represent relationships between the CSF's. And thirdly, because the essentials for successful SM described by other researchers can be reflected in the fifteen CSF's by Yang et al. (2009) or in one of the described core values. Therefore, the research of Yang et al. (2009) will form the basis for the evaluation tool, supplemented by studies of other researchers in the field.

Based on the studies referred to in the previous sections, Table 1 is generated as a first step to the evaluation tool.

Table 1: The four groups of the evaluation tool with the corresponding CSF's

Shared information input	Stakeholder estimation	Decision-making	Sustainable support
CSF 12: Project missions / Setting goals	CSF 10: Stakeholders' attributes	CSF 11: Conflict resolution	CSF 14: Change of stakeholders' influence and relationships
CSF 5: Full list of stakeholders	CSF 15: Stakeholders' behaviour	CSF 9: Formulating appropriate strategies	CSF 6: A steady relationship with stakeholders
CSF 4: Inventory and analysing stakeholders' interests	CSF 8: Potential influence	CSF 13: Predicting the reaction of stakeholders	CSF 3: Communicating with and engaging stakeholders properly and frequently
CSF 2: Their needs and constraints to the project / Inventory of issues	CSF 7: Conflicts and coalitions		CSF 16: Anchoring and monitoring agreements
			CSF 17: Evaluate working method and adjust procedures

3.3 Practical approaches and tools in stakeholder management of LIP's

The previous section presented four core values with associated CSF's to evaluate the performance of SM. This section provides insight into how these CSF's can be recognized in practice when examining design process of LIP's. Later, during the case studies, it will be investigated how this is incorporated in the V&V process of LIP's in practice. In this section, possible practical implementation will be elaborated per value of CSF's based on literature study.

3.3.1 Shared information input

When the project team engages in SM, there is current knowledge of the environment within the organization, i.e. obtained during project tender phase. This is valuable knowledge that can be incorporated into stakeholder and issue dossiers. These dossiers are useful for recording knowledge of issues and stakeholders. These dossiers are filled based on internal knowledge, possibly supplemented with public information from websites, newspapers, etc (Wesselink & Paul, 2015). The project team can also choose to organize a workshop or a so-called project start-up. A project start-up is a structured meeting of the future project organization in which it is often decided to invite stakeholders (Groote, Hugenholtz-Sasse, & Slikker, 2000).

A workshop or a project start-up is also useful tool to clarify the project missions together with the stakeholders. It is important to be aware of the different perspectives of the client, contractor and stakeholders. Therefore, when setting goals, it is useful to become aware of each other's ambitions first (Wesselink & Paul, 2015).

3.3.2 Stakeholder estimation

Thoroughly reviewing and analysing the previously prepared stakeholder dossiers is helpful in understanding stakeholders. Questions that could not been answered by the stakeholder dossiers should be included in a subsequent conversation with the stakeholders (Wesselink & Paul, 2015).

A useful instrument to estimate stakeholders is a power-interest grid. A power-interest grid arrays stakeholders on a twofold matrix, with the stakeholders' interest on one axis and the stakeholders' power on the other axis. Power-interest grids can help to determine which stakeholders must be taken into account in order to address the problem or issue at hand (Bryson, 2004).

In order to recognize the potential influence of stakeholders and their interrelations, various researchers are describing something similar. Stakeholder-influence networks (Ackermann & Eden, 2011), stakeholder influence diagrams (Bryson, 2004), and stakeholder influence mapping (Bourne & Walker, 2005) are instruments that use the power and interest of stakeholders as an input to understand the interrelation between the stakeholders. The action of a stakeholder can generate a dynamic of responses across a range of other stakeholders. In the same way, the power of a stakeholder can often be seen in relation to their position in the network of other stakeholders (Ackermann & Eden, 2011).

3.3.3 Decision-making

In decision-making, the goal is to create conditions that optimally contribute to working towards a solution that benefits all parties involved. Engagement of stakeholders in the decision-making process is widely recognized to improve the quality and equity of the decisions made and to limit protests afterwards (Ignaccolo, Inturri, Giuffrida, Le Pira, & Torrisi, 2017).

Available information is used to formulate an effective strategy to what extent to involve stakeholders. Participation levels can be used for this. A participation level is assigned depending on the stakeholders' interests and power, so a power-interest grid could offer help in this (Wesselink & Paul, 2015). The participation level determines the way in which the stakeholder gets involved in the decision-making. In determining a strategy, it is also important to examine the relationship with the stakeholder. Has a particular issue previously been discussed with a stakeholder? In a positive or negative way? This will influence the way in which the conversation with a stakeholder starts off.

In addition to the power-interest grid and the stakeholder-influence network, Ackermann and Eden (2011) recognized the need for another instrument to formulate strategies on how to manage stakeholders. Just as Wesselink and Paul (2015) indicate, they also believe that the strategy should depend on the interest and power of the stakeholder. They designed a so-called SM web based on the stakeholders' interests and power to determine appropriate strategies.

Ignaccolo et al. (2017) see visualizing a decision problem, for example by using simulation models, as helpful in participatory decision-making. By visualizing the decision problem, the preferences and opinions of the stakeholders can be captured. Furthermore, they mention the use of multicriteria decisions-making methods as "a first step of a stakeholder-driven decision-making process" (Ignaccolo, Inturri, Giuffrida, Le Pira, & Torrisi, 2017). Multicriteria decision-making methods can help in structuring the problem with different points of view.

To further avoid potential problems and conflicts in decision-making, it can be helpful to formulate the purpose of the decision and make agreements about time, money, quality, information and organization. In the decision-making, it can be helpful to have formulated a Best Alternative To a Negotiated Agreement (BATNA), the BATNA offers protection against agreeing to something you should reject (Wesselink & Paul, 2015). In this sense, Chinyio and Akintoye (2008) point out the use of trade-offs in the decision-making process. Trading-off can be a useful option when the expectations of stakeholders cannot be reached. If no consensus can be found on a certain subject, the project team can offer the stakeholder something else in order to keep them satisfied (Chinyio & Akintoye, 2008).

3.3.4 Sustainable support

During the process, effective communication is very important for maintaining existing relationships. Through communication, the project team can understand the expectations of its stakeholders as well as keep them informed. The frequency and extent of communication can be based on the previously determined participation level of a stakeholder. More impersonal means of communication like the use of newspapers and websites are useful for updating stakeholders when their urgency is not high, whereas stakeholders with high power and interest will expect to be kept fully informed and even get involved in the decision-making (Chinyio & Akintoye, 2008).

During communication, it is important to be aware that people and organizations may have different perspectives on a particular issue. An example of this is the issue of 'noise pollution'. One actor might describe noise pollution levels stating: "We comply with the legislation so we don't have a problem". While another actor might say: "There is a problem because there are many complaints". A mechanism that can help with this is 'Always check, never assume' ('ANNA' in Dutch). This mechanism helps to realize genuine interest (Wesselink & Paul, 2015).

Building reflection ('Bouwreflectie' in Dutch) can help in the interim evaluation of the working methods. Building reflection is a peer review during the project. It provides feedback on the attitude and behaviour of project managers and their team members. It tries to prevent misunderstandings and irritations by focusing on the manner of communication. Nowadays it is a widely supported instrument that is used on various complex projects (Cobouw, 2009).

3.4 Theoretical framework: An evaluation tool for stakeholder management

Based on various literature it is expected that a successful implementation of SM in relation to the V&V process helps in the coordination of the design with stakeholders. But, as mentioned earlier, putting stakeholder philosophy into project management practice remains a major challenge in present-day stakeholder research (Mok, Shen, & Yang, 2014). Therefore, a literature study is performed on the critical factors to implement successful SM and the possible practical implementations of these factors. This section presents the theoretical framework, which is used in this research to evaluate SM in relation to the V&V process during the design phase of LIP's. Given the lack of research into SM specifically aimed at the V&V process, this tool is based on research into SM focused on LIP's in general. This gives

the evaluation tool an adaptive character. The evaluation tool is presented in Figure 4. In this, the four core values are adapted for the evaluation of SM in relation to the V&V process and the underlying factors are provided.

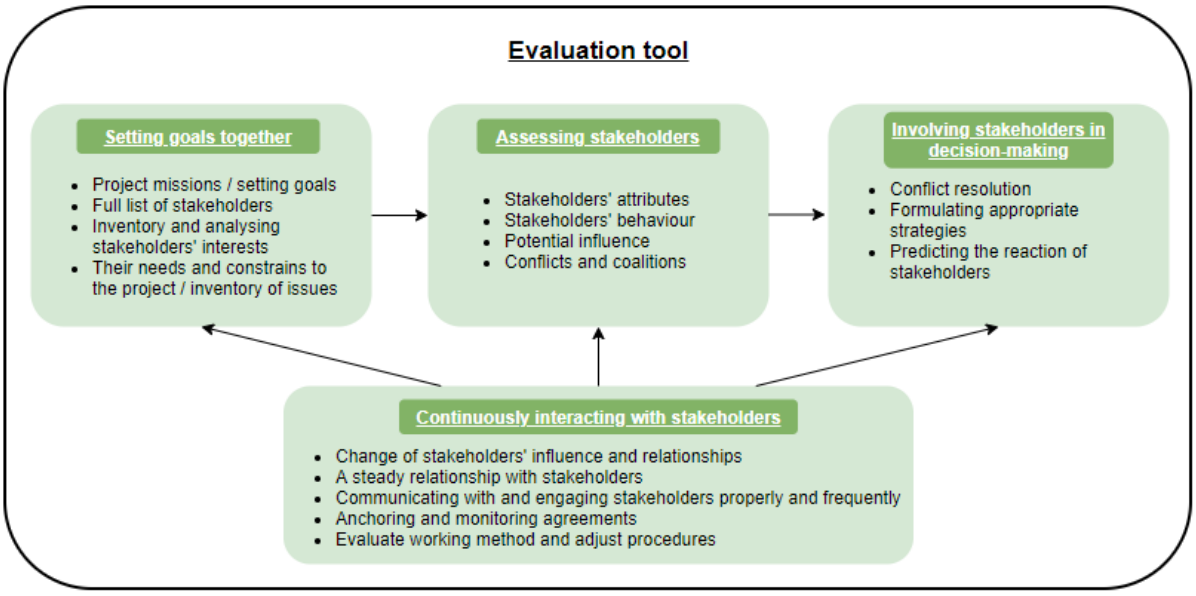


Figure 4: Theoretical framework to evaluate the performance of SM in relation to the V&V process.

The four SM core values are elaborated upon:

Setting goals together

SM strives to achieve a common goal while taking the various interests into account. This first group of factors tries to guarantee this by (1) setting a joint goals that (2) must be known among all stakeholders, (3) while taking into account the different interests and (4) possible needs and constraints to the project. Furthermore, it is examined whether the client and stakeholders were already in agreement with the requirements in the preliminary phase of the project. Section 3.3.1 describes how this core value can be recognized in practice.

Assessing stakeholders

To manage stakeholders during the project, it is necessary to be well informed about the stakeholders. In this research this core value is evaluated by analyzing what the client and contractor are conducting to assess the stakeholders. It is investigated how the client and contractor investigate the relationship of stakeholders to the project and to each other. Besides this, it is investigated whether stakeholders experience that the client and contractor are aware of them. Section 3.3.2 describes how this core value can be recognized in practice.

Involving stakeholders in decision-making

In the design phase, decisions are made about which design choices suit certain contract requirements. This research examines what strategies are used by the client and contractor to involve stakeholders in these decisions and whether these correspond with the factors described in literature. Besides, it is investigated whether stakeholders are satisfied with these strategies. Section 3.3.3 describes how this core value can be recognized in practice.

Continuously interacting with stakeholders

During the design phase, the project team should maintain sustainable support. It is investigated how the stakeholders are involved during the

V&V process in the design phase. On what frequency is there contact? Does it feel like open communication? Does the contractor or client check the changes in stakeholders' influence and relationships? Are agreements recorded and monitored? Do they have interim evaluation of their working methods? Section 3.3.4 describes how this core value can be recognized in practice.

4 Case study method

A case-study approach is applied to allow a deeper insight into how SM is performed in relation to the V&V process during the design phase in practice. This is to ultimately know how SM can help to improve the V&V of stakeholders' requirements. Besides, an attempt is made to gain insight into the effect of either a client or a contractor who coordinates the design with the stakeholders. This chapter elaborates on the methods to achieve these goals.

4.1 Introduction

According to Yin (2018), "a case study is an empirical method that investigates a contemporary phenomenon (the "case") in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident." (p.45). Swanborn (2010) uses a wider definition as he defines cases as *social systems* and a case study as *the study of a social phenomenon* which is performed within the boundaries of these social systems in its natural environment. The researcher studies the phenomenon during a certain period of time or by obtaining data from a previously executed case, in which the researcher focuses on analysing the process. This can be done by using various sources, such as available documents or interviews with those involved in the process (Swanborn, 2010).

In the execution of the case studies, answering the research questions must be the central focus (Swanborn, 2010). According to Swanborn (2010), performing case studies is a suitable approach if the research focuses on gaining understanding of various stakeholders with different, and sometimes conflicting, perspectives. The case studies aim to gain insight into the different perspectives on the involvement of stakeholders in the V&V process of the design phase. By analysing the different perspectives in the case studies, conclusions can be drawn about the way in which different applications of SM in relation to the V&V process relate to successful coordination with the stakeholders.

In order to perform reliable and valid case studies, there are four criteria in social scientific research. To meet these criteria, it is very important to design the case studies correctly and to analyse the processes used to collect and analyse data (Herling, 2000). The four criteria for the case studies are (Dooley, 2002):

- *Construct validity:* This criterion states that proper instruments must be selected for the concepts being researched and variations in the measurements must be justified by the concepts. The instruments used for the case studies are found in section 4.3.
- *Internal validity:* Various pieces of evidence must be collected in order to prove conclusions that suggest that some conditions are caused by or are the consequence of other conditions. Therefore, section 4.3 describes the various ways of collecting data that are selected for this research.
- *External validity:* This verifies if the findings can be generalized to other cases. Comparing the findings from the case studies with the findings from the literature study helps for this criterium.
- *Reliability:* It must be ensured that the research can be replicated. To make future research possible, this chapter elaborates on how data is collected and analysed and the interview protocol can be found in Appendix C.

4.2 Case selection

Cases must be selected that reflect the research scope to ensure validity of the research results. When choosing multiple cases, it is vital to examine each case in the same manner (Dooley, 2002). By selecting cases, the researcher is limited to the resources available and the scope of the research (Swanborn, 2010). As mentioned earlier, two LIP's are chosen to evaluate. The size of these LIP's prohibits analysing the entire V&V process of these projects within this study. Therefore, subprojects from these LIP's were selected and analysed as separate cases.

The reason to select two LIP's is to investigate the differences between a client and a contractor who is coordinating the design with the stakeholders. The Zuidasdok project and the ViA15 project meet this criterion. In the Zuidasdok project, the client is responsible for coordinating the design with the stakeholders. In the ViA15 project, this task is the responsibility of the contractor.

The Zuidasdok project, an important part of initiating this research, is an example where coordination with the stakeholders did not run smoothly. Within the Zuidasdok project, two cases are chosen to be evaluated, the subproject 'Technical Installation' (TI) and the subproject 'Public Transport Terminal' (PTT). These cases are selected in consultation with the stakeholder relationship manager ('omgevingsmanager' in Dutch) of the project. The coordination with the stakeholders went better in one case than the other case and it is therefore interesting to examine the cause to this difference. Further explanation of the cases within the Zuidasdok project can be found in the case descriptions in sections 5.1.2 and 5.1.3.

The other LIP is the ViA15 project. Within the ViA15 project, one case is selected to evaluate in consultation with the stakeholder relationship manager of the project. The case within the ViA15 project is the subproject 'Subarea 4'. In the third case, the coordination of the design with the stakeholders is also going well. Further explanation of the case is found in the case description in section 5.2.2.

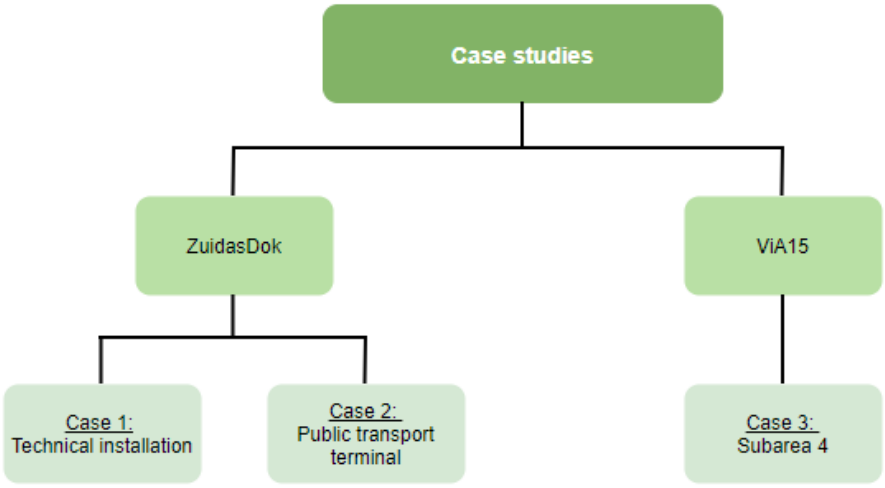


Figure 5: Case selection

4.3 Data collection

This section describes the protocol used to collect data, it describes which data is collected and how the data is collected. This protocol for collecting data will be repeated in each case and can be used for future research, ensuring the reliability of this study. The case data is collected in two ways: through document analysis and by conducting interviews. By analysing the project documents, insight is gained into the characteristics of the cases. The interviews are used to observe how SM is applied in the design process, what the possible improvement areas are and what stakeholders experience as a pleasant way of working.

Document analysis

Before zooming into the specific cases, the two LIP's are introduced in a short overview. This overview gives an introduction of the LIP, describing the project area, the project goal, the project scope, and more factual characteristics. An overview of the cases is also presented with an explanation of the specific scope of the sub-project, the intended structure of the design process and the organizational relationships are investigated. Data for this overview will be collected through general project documents available online or in the database of HOCHTIEF.

Interviews

The aim of the interviews is to analyse, based on the previously obtained four SM groups, how SM is applied in relation to the V&V process during the design phase, what possible points for improvement are and what stakeholders experience as a pleasant way of working. To gain an understanding of the different perspectives of the client, contractor, and stakeholders, semi-structured interviews are chosen. In semi-structured interviews, the topics are predefined, open questions are used and there is room for follow-up questions. This provides the freedom to discuss certain topics in detail. The evaluation tool, Figure 4, is used to structure the interviews and to define the topics to discuss. In order to select the right respondents from the client, contractor, and stakeholders and to make sure that every respondent debates the same process, several subjects are selected which are discussed during the interviews. The subjects are parts of the design where there has been much discussion about the requirements and/or accompanying amendments. These subjects will be discussed in the description of each case (section 5.1.2, 5.1.3, and 5.2.2), as well as the selection criteria for the interviewees. Further information about the complete interview protocol can be found in Appendix C.

4.4 Data analysis using an evaluation tool specific for the V&V process

In order to correctly analyse the collected data, we determine in advance how the data will be analysed to derive an answer to sub-question 2. As mentioned earlier, the extent to which SM is applied is evaluated based on the evaluation tool previously obtained from the literature review in Chapter 3 shown in Figure 4. This is guaranteed by drawing up the interview questions using this tool.

The interview reports were then analysed based on the various core values of SM with their underlying factors. The analyzed interview reports can be found in Appendix D. The respondents mentioned various activities that in their view are a form of SM that contribute to the V&V process. These are described below:

Requirement analysis	Requirements are formulated based on the wishes and needs of stakeholders. In addition, requirements can sometimes be interpreted in different ways. By means of the requirements analysis, these underlying wishes and needs are analysed and a correct interpretation of the requirements is recorded.
Design meetings	During these meetings, the current design is discussed.
Review moments	At the end of each design phase, the current design is reviewed by the client and the stakeholders. They provide comments and are able to reject the design.
Stakeholder files	The interests, wishes and issues of the stakeholders are included in these files.

5 Case studies

This chapter presents how SM is performed in relation to the V&V process during the design phase in practice. This examines how stakeholders are involved in the step from a contract requirement to design choice. This has been investigated in three different cases using the evaluation tool previously obtained from the literature review in Chapter 3, making it an empirical study based on scientific research. In each case, interviews were held with people from the client and contractor who were responsible for verifying and validating the requirements and the corresponding coordination with the stakeholders and interviews were held with stakeholders who had given requirements to the project. In addition to examining the SM carried out in relation to the V&V process, it is investigated what respondents indicate as possible points for improvement and what stakeholders experience as a pleasant way of working. In this chapter, the results are presented per perspective if the respondents of the contractor, client, or stakeholders had different views on a particular topic. This means the perspective on a particular SM value related to the V&V process of the design phase.

5.1 The Zuidasdok project

5.1.1 Project description

The Zuidas is well on its way to living up to its vision of the future as an international top location with excellent accessibility. Amsterdam South station has therefore been designated as a National Key Project ('Nationaal Sleutel Project' in Dutch) by the Dutch government. Several bottlenecks still stand in the way of this development, which the realization of the Zuidasdok project aims to solve. The two major bottlenecks are an insufficient traffic flow on the A10 and a capacity problem at the Amsterdam Zuid station.

Through the Zuidasdok project, an attempt is being made to resolve these bottlenecks by widening and rerouting the A10 highway underground, and expanding and modernizing the Amsterdam Zuid railway station. The location and scope of the project can be found in Figure 6. As mentioned earlier, two sub-projects of this project have been selected to investigate as case studies, namely the TI and the PTT. The cases are further elaborated in sections 5.1.2 and 5.1.3.

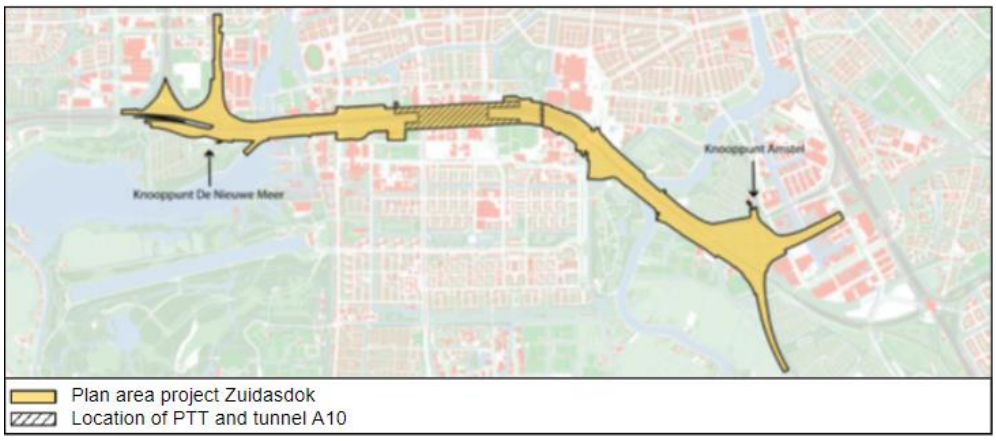


Figure 6: Project area Zuidasdok

The Zuidasdok project is located in an administratively complex environment. A joint project organization which is called Zuidasdok has been formed as the client, consisting of employees of Rijkswaterstaat, ProRail and the municipality of Amsterdam[7]. Although the client consists of various organizations, their starting point is to function as one client in the relationship with the contractor and stakeholders. ZuidPlus works on behalf of the client and is the contractor of the project, ZuidPlus is a consortium consisting of

[7] When in case 1 or 2 reference is made to 'the client', this organization is meant.

Fluor, HOCHTIEF and Heijmans[8]. After completion, the station will also have three end operators: ProRail for the train section, Metro & Tram for the metro section and NS Stations for the commercial functions. ProRail is therefore involved as both the client and the end operator (i.e. stakeholder) of the project. Since Metro & Tram is part of the municipality of Amsterdam, the same applies to that organization. The tender represents a contract value of € 990 million, making it one of the largest infrastructure projects in the Netherlands at the moment. The project is funded by the State, the municipality of Amsterdam, the Amsterdam Transport Region and the province of North Holland.

The contract of the Zuidasdok project was awarded to ZuidPlus in 2017. As explained in section 2.3, the case studies focus on the design phases. The design phase is divided into a preliminary design phase, final design phase and an implementation design phase. The contractor and the client, unfortunately, terminated the contract at the beginning of the final design phase in June 2020. Since then, the client (and part of the contractor) is working on the final design. The case studies focuses mainly on the preliminary design phase, and thus on the phase immediately after the contract award.

5.1.2 Case 1: Technical installation

In this case, SM in relation to the V&V process of the subproject is investigated during the design phase that is concerned with the TI's of the Zuidasdok project. There is a separate department within the organization of the contractor who is responsible for all TI's in the entire project, the TI department. The department is responsible for the TI's of the tunnel, dynamic traffic management, station-related installations and TI's in the public space, so it has interfaces with other disciplines of the project. This case study focuses on the technical installations of the tunnel and the station-related installations.

Rijkswaterstaat manages the State tunnels and has a separate organization within their company that is responsible for this, hereinafter referred to as tunnel operator. An important subject for the tunnel is the National Tunnel Standard ('Landelijke Tunnelstandaard' in Dutch), which has been added to the contract by the tunnel operator as a set of requirements. An important part of the National Tunnel Standard are the specifications of the Rijkswaterstaat tunnel system. This describes the functional requirements, processes, design and layout of the tunnels. During the project, this National Tunnel Standard changed which resulted in amendments of the contract. During the interviews, the way in which the tunnel operator was involved in these amendments was discussed.

Another subject that was discussed during the interviews is the Plug & Play document that was added by NS Stations as a set of requirements to the contract. NS Stations will become the operator of the commercial facilities at the station and has drawn up requirements for this by means of this Plug & Play document. It specifies, among other things, what kind of installations must be connected, such as electricity and heating systems. During the project, NS Stations wanted to make a change to this Plug & Play document which resulted in amendments of the contract. In the interviews, the way in which NS Stations was involved in these amendments and the consequences it had for the design were discussed.

The TI department set up its own V&V process and supervised that work was carried out according to the set up plan. A requirements analysis was first performed by the entire team and the requirements were assigned to people within the team. The V&V process was therefore picked up jointly by the designers of the TI department. During the interviews it emerged several times that the SE methodology is already deeply rooted in the world of installation technology.

In order to investigate how stakeholders are involved in the step from requirement to design choice in the V&V process, interviews are held with various people of the client and contractor who were responsible for the design and with people from organizations that are called stakeholders in this project. These are operators of the tunnel and train. This comes down to the following respondents:

[8] When in case 1 or 2 reference is made to 'the contractor', this consortium is meant.

- From the contractor[8]:
    - The manager of the TI department. As head of the TI design team, he was responsible for the sub-project and made sure that contact was maintained with the client and stakeholders during the design phase.
    - The design manager station-related installations. He was head of the design team concerning the station-related installations and from there he was responsible for contact with the client and stakeholders during the design phase.
- From the client[7]:
    - The design manager station-related installations. He had the same role as the design manager of the contractor, they were in close contact with each other. In this role, he had the responsibility, among other things, to involve the stakeholders if the contractor and client consider this necessary.
- From the stakeholders:
    - Director commissioning ('Regievoerder ingebruikstelling') at Rijkswaterstaat. In that role he is responsible as tunnel operator at Rijkswaterstaat.
    - The manager service development of NS Stations. From his organization he was responsible for the Plug & Play document. However, he mainly had to do with the project team of the PTT and therefore the findings of the interview with him are listed under case 2.

5.1.2.1 Setting goals together

In case 1, the respondents mentioned several activities that were carried out at the beginning of the design phase that led to mutual understanding and common goals were set. The respondents of the client and stakeholder indicated that a start-up activity has taken place. The client explained that the contractor organized this kick-off meeting in which they gave a presentation about the process that they had in mind and all kinds of project plans were presented, including the V&V plan. Although the respondent of the client was not sure whether concerns of the stakeholders were already discussed during that kick-off meeting, the respondent of the stakeholder indicated that this was indeed done. As the stakeholder' respondent said: "*Very comprehensive! With entire tribes, when it was still possible before the corona virus. A kind of working day, closed with beers and bitterballs. In order to achieve two things: 1) So that people get to know each other and also know where to find each other when necessary. And 2) So that it is clear what the purpose of the contract is"*. It is remarkable that, while the stakeholder indicated that the start-up activity has been very exuberant, both respondents of the contractor stated that there was no start-up activity with stakeholders to establish joint project goals. As one of the respondents said: "*No, not with stakeholders involved. We only encountered stakeholders later*". Furthermore, the contractor was not aware of issues stakeholders had to the project or their interests at the beginning of the design phase, "*you only notice that when you start talking to those parties*". One of the respondents indicated that there were not many issues either, neither at the beginning nor the end.

Respondents from both client and contractor emphasized the importance of a carefully executed requirement analysis at the beginning of the design phase. The design team of the contractor has paid a lot of attention to this concerning this case. The requirements analysis must ensure that all requirements are formulated SMART. Due to the fact that requirements are interpretative, they believe it is important to get everyone on the same page as soon as possible. In the event of uncertainty about a requirement or a change in requirement, it must be carefully agreed what the meaning is at the beginning. The client is always the first point of contact for the contractor, but if they cannot reach a solution together, they involve the stakeholder. With that, the client and contractor had a joint approach to involve the stakeholders as much as possible. One of the respondents stated that: "*A characteristic of good SM is that you write everything down well together at the front and that you monitor it well*". The stakeholder was also very pleased with the requirement analysis, as the respondent put it: "*specify properly at the front so that we can demonstrate at the back that we meet the legal requirements and*

obtain a permit to operate the tunnel". Furthermore, the stakeholder's respondent indicated that at the start of each design phase, the contractor discussed how they intended to implement the requirements.

Although the contractor was, in their own eyes, not really aware of the interests of the stakeholders at the beginning, one of the contractor's respondents indicated that their interests were openly discussed with the client. He said: "*And in fact, you should then try to look from that common interest that you have, to: how are you going to tackle that?*". Furthermore: *"In my view, you should always keep a close eye on the other's interests"*.

Conclusion

An interesting finding is that the contractor was no longer aware of a start-up activity to which stakeholders were invited, while the client indicated that it was organized by the contractor and the stakeholder indicated that this activity was handled very exuberantly. The contractor does, however, emphasize the importance of good agreements with each other at the start and monitoring that these agreements are being pursued. The stakeholder also emphasized that they were very satisfied that the contractor discussed at the beginning of each phase how they intended to interpret the requirements.

So, it seems that the contractor has indeed invested in a start-up activity at the beginning of the project to get to know each other. Furthermore, the requirement analysis seems to play a major role to set joint goals (getting agreements about the interpretations of the requirements) with the relevant stakeholders while discussing each other's interests and possible needs and constraints to the project.

5.1.2.2 Assessing stakeholders

Not much has been done on this value of SM, at least not by the contractor. However, the tunnel operator is convinced that both the contractor and the client were well informed of their organization. In the preliminary phase of the project, before the contract was awarded to the contractor, the client made stakeholder analyses. The client's respondent told that these stakeholder analyses have not been shared with the contractor, but explained that the requirements are partly based on these analyses. In that way, the contractor is informed of the interests and concerns of the stakeholders. A remarkable finding, however, is that the client's respondent indicated that the contractor is being informed from which stakeholder a requirement originates, while a contractor's respondent indicated that they are not being informed about this. Besides to the contract requirements, the client's respondent told that a process specification has been added to the contract, *"it states, for example, with which party the contractor can further coordinate on certain components".*

The design team of the contractor did not made analyses to assess the stakeholders, both respondents of the contractor believe that this would have had added value. One said: "*A: you know that, and B: it will surface in the process anyway"*. The contractor's respondents indicated that they unconsciously made estimates of the other parties based on experience (both of the respondents were very experienced in the field). Nobody from the stakeholder relationship department was involved in the design process and the respondents do not see the advantage in that either, *"only if the communication between the parties is difficult"*.

The tunnel operator has the firm impression that the client and contractor were well informed about his organization. Added to that he said: "*If only because of the frequency with which we sat around the table. For example, we had a technical tunnel meeting every two weeks"*. These technical tunnel meetings were chaired by the responsible design managers of the contractor with the client and his organization present. Furthermore, he said: "*I think we (the client, contractor, and his organization) have had a clear picture of how the organizations work and what the interests of each other are*".

Conclusion

It is remarkable to see that the contractor has not made a formal assessment of the various stakeholders, while the stakeholder on the other hand has had the firm impression that the contractor was well aware

of his organization. The contractor also indicated that they do not see the benefit of a formal stakeholder analysis, and based on the findings, they may be right about that. The client has made a formal stakeholder analysis and has drawn up the requirements for the contract partly based on that analysis. In combination with a carefully performed requirement analysis, it could be that the contractor was indeed unconsciously informed of the interests of the stakeholders as a result. Besides, the two weekly meetings gave the stakeholder the feeling that the contractor and client were well informed about their organization. Since the respondents of the contractor indicated that they made their assessment of the stakeholders during the discussions unconsciously and based on experience, the two weekly meetings may indeed have contributed well in estimating the stakeholders.

5.1.2.3 Involving stakeholders in the decision-making

All respondents see the formal review moments as the way in which stakeholders have been involved in the decision-making during the design process. At the end of each design phase, the contractor sent the design documents to the client to review. These documents were then distributed by the client to the stakeholders who were given the opportunity to give comments. Stakeholders provided their comments through formal review lists to the client, after which the client returned it to the contractor. The tunnel operator told that this gave his organization the opportunity to validate whether the design met their expectations. He explained that during these review moments they jointly tick the boxes for requirements that were met. As an example, he mentioned a requirement that states that the tunnel installation must have an air flow of 2.5 m/s to get toxic substances and smoke out of the tunnel as quickly as possible. Then he looks at the design file that contains a test report with measurement results that indeed demonstrate that there is an air flow of 2.5 m/s. Further he mentioned: "*And sometimes we have requirements that are almost met but cannot possibly meet the standard exactly. So then we will discuss this and then we can have a deviation about it"*. The contractor's respondents believe that it is important that the client is given the opportunity to first determine whether an initiated amendment of a stakeholder should be implemented and subsequently discuss it with the contractor. One of the respondents said about this: *"You must always have it done through the client because if comments from the stakeholders deviate from the contract, or if a stakeholder initiates an amendment, this has contractual and financial consequences. And you have to give the client the opportunity to filter that"*.

In addition to the review moments, stakeholders were involved when there were uncertainties about requirements or amendments to the contract. In that case, joint sessions were organized where the contractor, client, and stakeholders came to decisions together. The tunnel operator indicated that he is satisfied with how his organization has been included in the decision-making during the project. He described how they felt like they were looking over the shoulders of the design team and became involved in the design choices that were made.

Conclusion

The stakeholder is satisfied with how he was involved in the decision-making during the design phase. The contractor, client, and stakeholder see a major contribution from the review moments at the end of each design phase for involving the stakeholders in the design process. During the review moments, the stakeholders were informed about the design choices that the contractor had made, so they were not part of the decision-making but had a say in whether or not to approve the design. During the process, the contractor involved the stakeholders in making design choices if there were uncertainties about the requirements. Stakeholders were also involved in decisions when amendments were made to the contract. So the contractor and client did not involve stakeholders based on previously acquired assessment about the stakeholders but mainly involved stakeholders if they ran into something.

5.1.2.4 Continuously interacting with stakeholders

It seems that much attention is paid to sustaining support from every party involved. Stakeholders were frequently involved during the process. Open communication took place between the parties and agreements were recorded and adhered to. The contractor organized design workshops with visualizations and design meetings took place in the presence of the client, contractor and stakeholders.

Because the respondents of the different parties describe various activities that have been carried out in this category, this section describes the findings per perspective.

Contractor's perspective

The design manager of the project team emphasized the importance of good guidelines several times and the importance to ensure that everyone adheres to them. For that reason, the general V&V plan for the project was made specific within their project team and they adhered to a plan that described, among other things, how to deal with the client and stakeholders. He cites as an example: "*Stakeholders are involved during design workshops with visualizations and the 3D model in the realization of the design. The effect of this measure is to create support for the results of the integral design phase*".

An important realization, which was repeatedly emphasized by one of the respondents, is that the insights of the parties change over time. Therefore, as he stated: "*you have to stay on speaking terms very intensively with your end operator and talk about how things are going to be*". Added to that, he said: "*Information sessions, sharing the designs, discussing design choices, discussing design decisions, and so on. Sharing everything with each other, we think it should be this way*". The other respondent emphasized: *"our starting point from the beginning has been to involve stakeholders as much as possible in discussions"*. Involving stakeholders had to be done through the client, which both of the respondents thought worked well. Together with the client, it was often decided to involve a certain stakeholder in the design process, in their view there was always agreement on this. As one of the respondents stated: *"In that respect, the collaboration at TI went well, both with the client and the underlying stakeholders"*.

Later in the project there was also some direct contact with the stakeholders, about which the client was always informed. One of the respondents mentioned the amendments to the Plug & Play document as an example. There was a lot of discussion about how the amendments needed to be interpreted, which is why there was a lot of direct contact with the stakeholders. He said: *"We discussed and coordinated a lot with the NS, which was attended by someone from the client. And that works well, if you sit directly with the people for whom you are actually building such an installation"*.

They indicated that this was also their strategy for creating and maintaining support from the stakeholders and that they received positive feedback from the stakeholders about this. They believe that the requirements analysis and the review moments played an important role in maintaining support from the stakeholders. Within the project team, their approach was evaluated in the interim and they tried to propagate this to other disciplines, "*but they never got around to it*".

Client's perspective

In addition to the formal review moments, the client's respondent finds it important to informally involve stakeholders in the design process. When asked when he considers the V&V of a stakeholder requirement to be successful, he answered with: "*When a stakeholder is satisfied. I think it is very good to include a stakeholder in the process. It should come as no surprise to the stakeholder what she or he ultimately receives. If you properly involve a stakeholder in finding a solution, a solution that meets the requirements, and also provides a kind of warm transfer, an explanation. Then you ensure understanding from a stakeholder"*. He indicated that there was a monthly consultation with the stakeholders, the client, and the contractor and that the design meetings played an important role in creating and maintaining support from the stakeholders. Everything that was discussed in the meetings was also recorded and included in the design notes. He indicated that by following the V&V process, interests were raised and discussions could be held.

Furthermore, he indicated that there was a very open way of communication and therefore good cooperation between the client and the contractor. As he said: "*if there are really things in which we differed in opinion, then that just came up and then it was discussed"*. He felt they had the same mindset when it came to involving stakeholders in the design phase. He also said that in some projects he sees

that the client and contractor are far more distant from each other and that in his opinion this often goes wrong.

Stakeholders' perspective

The tunnel operator is convinced there was support from his organization for the project. In his eyes, the client and contractor ensured that by: "*In the initial phase, we invested well in getting to know each other and the project, in terms of process and content. We have had a good work structure with open communication. So I don't think there is any need for improvement or change"*. He explained that his organization was involved in such a way that it felt as if they were looking over the shoulders of the designers during the design process. He said that there have been a whole series of interactive sessions and conscious attention has been paid to discussing each other's interests. He is positive about their cooperation with the contractor and client. He felt that the contractor always took the lead in organizing the meetings, drawing up the agendas, and recording and monitoring appointments and did not feel that anyone had ever commented on this.

Furthermore, the tunnel operator pointed out that the national tunnel standard ('Landelijke Tunnelstandaard' in Dutch) plays a major role in the realization of a tunnel. This is a standard, based on the SE principles, that is laid down by law and describes how the process must be completed, including how the stakeholders should be involved. It is therefore a legal obligation for the client and contractor to involve the stakeholders in a certain way. For example, they have had a specific consultation structure, which meant that they had a tunnel technical consultation with the contractor every two weeks. In addition, there was a specific safety meeting in which the design of tunnel technical installations was discussed with the design team.

Conclusion

It can be concluded that there was a very open communication where both the contractor and client had the mindset to involve stakeholders as much as possible in the design process. The stakeholder was convinced that there was support from his organization for the project. In his view, this was due to a good introduction and work structure with open communication.

System engineering is already quite a deeply rooted discipline within installation technology, and this is reflected in the interviews. Not only the contractor's respondents but also those of the client and even the stakeholder spoke in terms of SE when describing the V&V process carried out by the TI department. The TI department made the general V&V plan of the project specific to the sub-project and strived to ensure that everyone within their department followed that plan. The client indicated that by following the V&V process, interests came up and discussions could be held with the involved parties. Furthermore, the contractor structurally adhered to a plan that described, among other things, how they had to work together with the client and stakeholders. By structurally following the project plans and an open way of communication, it seems that the parties were close to each other. The client's respondent said that agreements were made and shared with the parties. Furthermore, the contractor held interim evaluations of their working method, during which it was discussed whether stakeholders were sufficiently involved in the design process. According to one of the contractor's respondents, they tried to propagate this to the other disciplines, but they did not get around to it.

5.1.2.5 Conclusion case technical installation

In this case, a lot of work was done according to the previously drawn up plans, in which, among other things, it was indicated at what frequency to contact the stakeholders. Every party (client, contractor and stakeholder) seemed aware of these plans and expressed their satisfaction. By formally following those plans, a lot of SM was carried out, which is shown per SM group in Table 2.

Table 2: Conclusions of case 1 per SM group

Part of SM	Conclusions
Setting goals together	The carefully conducted requirement analysis probably played an important role in bringing the parties together from the beginning of the design phase. In this way, the underlying interests were brought up and the parties involved jointly agreed on how requirements would be approached during the design process. The parties were satisfied with this, and the stakeholder has also indicated that it is important to pay a lot attention to setting goals together.
Assessing stakeholders	At the beginning of the design phase, no formal analyzes to estimate the stakeholders were carried out, but several activities were organized to get to know each other. The parties are satisfied with this, therefore the contractor also does not believe that formal analyzes are necessary.
Involving stakeholders in the decision-making	Stakeholders were involved in decision-making at the end of each design phase through formal review moments, where they were briefed on the design solutions and given the opportunity to give comments and the possibility to reject the design. In addition, stakeholders were involved during the process if there was uncertainty about a certain requirement or if there was a deviation from the contract. The parties seem to be satisfied with this way of involvement.
Continuously interacting with stakeholders	All parties agreed that there was an open way of communication and told that there was frequent contact during the design phase, once every two weeks. It probably helped a lot that all parties involved had a common understanding of how the design process should be organized, namely according to the SE principles.

All parties have indicated that they are satisfied with the progress of the design phase and the cooperation between the parties. The close cooperation in which interests always came directly to the table probably ensured that there were few surprises for each other and that joint efforts could be made towards a final result.

In the V&V process of the design phase, in this case, the most effort seems to be put in the first and fourth group of SM. Since the stakeholder indicated that he is satisfied with the amount of attention that was given at the beginning to getting acquainted and setting goals together, this will likely have contributed to the client's and contractor's awareness of their organization. As a result, it was probably less necessary to perform entire analyses to make estimates of stakeholders. Furthermore, the stakeholder felt as if they were looking over the shoulders of the designers in the design phase although they were only involved in making decisions when amendments to the contract were at play and at the review moments. This probably has to do with the effort which is put in the fourth group of SM, stakeholders were frequently involved and there was an open way of communication.

The client and contractor were on the same page as to whether or not to involve stakeholders in the design process. The respondents of the contractor and client agree that contact with the stakeholders can best be done through the client, so that the client can monitor the contract and oversee the possible consequences. Nevertheless, it felt to the stakeholder as if the contractor took the lead in organising meetings, this will probably be due to the close cooperation between the parties. It is the experience of the client's respondent that projects often go wrong when the client and contractor do not have a close relation.

5.1.3 Case 2: Public transport terminal

In this case, SM related to the V&V process of the subproject is investigated during the design phase that is concerned with the PTT of Amsterdam Zuid. The realization of the PTT is a large part of the total

project scope , it costs about one third to half of the total project sum. The sub-project is located in a complex environment with many interfaces, which means that many requirements of different stakeholders are related to each other.

One of the subjects, discussed during the interviews, was the requirements and changes in requirements related to a vertical point of ascent. This vertical point of ascent includes an elevator, escalators and regular stairs and is located between two metro tracks. This topic has been a key discussion point for the project as it was unclear for a long time how to design the part, probably due to the many interfaces between the different parties involved. Another subject was the requirements and changes in requirements with regard to the realization of the metro entrance building. When designing the metro entrance building, the contractor soon realized that there were uncertainties about the requirements set by the metro operator. The interviews made it clear how the various parties think about this. These examples show that several transport providers struggled in the V&V process with persistent uncertainties about important design choices from which a lot depended.

The contractor has made a separate department, Integral Assurance department, responsible for setting up the V&V process for the PTT. This department took a close look at the requirements of the contract and allocated them to what they considered suitable people from the contractor's design team of the PTT. The person who received the requirements made their own judgment as to whether the requirement had been properly assigned to them and then carried out the V&V of that requirement themselves. The V&V process therefore had an individual approach in this case.

In order to investigate how stakeholders are involved in the step from contract requirement to design choice in the V&V process, interviews are held with various people of the client and contractor who were responsible for the design and with people from organizations that are called stakeholders in this project. These are end operators of the metro and train. This comes down to the following respondents:

- From the contractor[8]:
    - The design coordinator of the PTT, who explained that he was in the management of the PTT design team and took on many of the design manager's responsibilities as they changed frequently. He had a lot of interaction with the end operators of the station.
    - The project leader PTT (first of the whole sub-project and later only for the non-track supporting constructions).
- From the client[7]:
    - The design manager of modifications to metro, tram and bus who was at the same time construction manager of metro, tram and bus. He explained that he joined the project organization on behalf of the municipality of Amsterdam, from that role he had the assets of the municipality of Amsterdam in his portfolio. In that role, he interacted a lot with the end operators of the assets of the municipality of Amsterdam, such as metro, tram and bus.
    - The technical manager of the client. He also coordinated the design with the stakeholders.
- From the stakeholders:
    - The asset manager from the metro operator GVB of this project.
    - The manager service development of NS Stations. From his organization he is responsible for keeping the station functional during the realization of the project and he monitors the contract that his organization has with the client about the future commercial units at the station.

5.1.3.1 Setting goals together

The interviews show that there was a great distance between the parties at the beginning of the design phase. There was little cooperation, which meant that the parties were not well aware of each other's interests and they did not invest time in setting goals together. During the preliminary phase, however, there was a lot of contact between the client and stakeholders to formulate the requirements for the contract. In those meetings, the wishes of the stakeholders and the applicable regulations were discussed. The client has checked the applicability of these wishes and regulations in a reference design and then included this reference design in the contract. All respondents agreed that when the design phase began and the contractor became involved in the project, too little time was invested in setting goals together. For example, no requirements analysis was carried out, which is seen as a lack by every respondent. This section elaborates on the perspectives on these findings of the parties involved and presents the possible areas for improvement mentioned by the respondents.

Contractor's perspective

One of the respondents indicated that at the beginning of the design phase they were not well aware of the possible issues from the stakeholders with respect to the project, he said: *"The client did not involve us (the contractor) in this, we simply received a contract with all the requirements we had to meet"*. According to both respondents, contact with the stakeholders went through the client and they were hardly involved in it. One of them thinks that the client has approached the stakeholders too individually and therefore no joint agreements have been made, as he stated: *"But this station is always integral, all issues you encounter are integral. So also in SM, if there is an issue then you should not talk to stakeholders individually"*. As an example he mentioned the requirements regarding the vertical point of ascent. Various stakeholders had set requirements for parts of this vertical point of ascent, but the contractor discovered during the design process that these requirements were in conflict with each other. After reporting this to the client, the client individually approached the stakeholders each time to ask if they saw the opportunity to adjust their requirements. However, no stakeholder gave an agreement and the client came every time to ask whether the contractor wanted to develop an alternative. After a while, however, the contractor ran out of options. Then the client called all relevant stakeholders together and came to a decision together, but it took a year and a half before that happened.

As mentioned, the PTT project team did not jointly conduct a requirements analysis at the beginning of the design phase. Only a few requirements were discussed with the client during the tender phase, but most of them were only discussed when the contractor encountered unclarities during the design process. One of the respondents saw the disadvantage of this but explained that the design team of the contractor was not motivated to perform a requirements analysis because they had been instructed by the management of the contractor to derive as few requirements as possible. According to him, this had several reasons, firstly they wanted to prevent an enormous amount of requirements being added to the project, which would make it more complex. In addition, no time was seen for an extensive requirements analysis. And according to him, the design team had little insight into it anyway because a separate department had been made responsible for the SE related parts of the project. It seems that because a department separate from the design team was responsible for setting up the V&V process, which ran simultaneously with the design process, the design team did not feel responsible for SE related parts of the project.

Client's perspective

According to both respondents of the client, the contractor started on the design too quickly and worked on that too individually when the design phase started. Rather than fathoming the requirements, they believe the contractor has started designing based on the reference design without first agreeing with the client and stakeholders what the intent of the requirements is. One of the respondents thinks that it would have been better if they did not include the reference design to the contract so that the contractor would have been forced to begin to analyze the requirements.

In their view, it was not ensured in the beginning that all parties (client, contractor, and stakeholders) involved worked towards the same goals. Although one of them did indicate that they talked about striving for a common goal during integral design meetings with all parties involved. One of them sees a requirements analysis as a very important first step in the design process. He believes that by carrying out a requirements analysis, a contractor becomes aware of the underlying interests and concerns of the stakeholders and thus gets a better picture of the purpose of the requirements. Besides, he believes that it gives the stakeholders the feeling that they are involved if you agree with them on how a requirement should be interpreted. The client had prepared the stakeholders in advance for a requirements analysis, so they had reserved capacity for this. However, this was not carried out, consequently stakeholders often asked about the status of the design.

One respondent gave an example where, in his opinion, it did went well, namely at the metro entrance building. There, the contractor discovered at an early stage that the requirements were not described SMART enough and would therefore not be able to carry out their V&V process properly. The contractor and client went to the relevant stakeholder together to conduct a requirements analysis. As one of them said: "*you have to understand what the intention is of a requirement. Then it is useful to go there so that the end operator can explain that*". He explained that this example concerned a single stakeholder and that subjects with multiple stakeholders did not get off the ground, he does not know why.

Stakeholders' perspective

GVB

The respondent explained that in the preliminary phase of the sub-project, the GVB added a package of requirements to the contract. This was a dynamic document in the preliminary phase, but in principle, those requirements were frozen from the start of the design phase. The respondent did not express himself very positively about how his organization was involved in the preliminary phase, which, in his opinion, also differed per project leader who was responsible at that time. The respondent did not say anything about a start activity at the beginning of the design phase, he only said: *"What you see is that they are now testing: we came up with this, what do you think about it?"*. So if design choices have been made, the contractor sometimes asks this stakeholder whether they agree. But they do not appear to be structurally involved and they are not involved in setting goals together at the beginning of the design phase.

NS Stations

NS Stations also added several packages of requirements to the contract during the preliminary phase. The respondent indicated that it is difficult to say whether his organization was satisfied with the preliminary phase, *"it is difficult to talk about satisfaction of something that took ten years"*.

The respondent noticed a lot of distance between the client and the contractor at the beginning of the design phase, as a result, he said, his organization was not really involved. He further told that meetings were organized to discuss each other's interests, but he is unsure whether this happened at the beginning of the design phase.

Furthermore, he said: *"I can say what I want to the client, but if he does not have the same interest, he will never convey it to the contractor in that way. You always have that link in between"*. He referred to the fact that the client has people from ProRail who have a different interest than the NS. For that reason, when his organization wanted a major change to the Plug & Play document, they consciously made sure that they got around the table with both the client and the contractor (which was with the design team of TI). This is not the standard procedure, but it did allow them to convey their interests directly to the design team of the contractor.

Conclusion

At the beginning of the design phase, no start-up activity was organized where each other's interests were discussed or common goals were agreed upon. Although common goals were set in the

preliminary phase by the client and stakeholders when formulating the requirements, the contractor did not discuss these with the client and stakeholders at the beginning of the design phase. One of the stakeholders indicated that the great distance between the contractor and the client meant that his organization was not really involved.

Multiple respondents believe that a requirement analysis could offer help. By conducting a requirement analysis parties could become aware of the underlying interests and concerns behind the requirements and thus gets a better picture of the purpose of the requirements. This could ensure that the different parties also come closer to each other in the design process from the beginning.

5.1.3.2 Assessing stakeholders

The design team of the contractor did not make formal assessments of the stakeholders, the information about the stakeholders came in through the requirements. As one of the contractor's respondents said: "*the train of thought is that what the stakeholder wants is stated in the requirements"*. However, according to many, the requirements provide insufficient information about the underlying interests of the parties. In the following sections, the different perspectives on these findings are presented and possible areas for improvement are described which have been identified by the respondents.

Contractor's perspective

One respondent indicated that formal assessments of stakeholders did not seem necessary since they mainly had discussions with stakeholders who were part of the client's organization and were not allowed to talk to the other stakeholders. One of the respondents indicated that a separate department (stakeholder relationship management) has made analyses about the stakeholders and it seems to both respondents a wise decision to involve someone from this department in the design process in the future.

According to the contractor, the many different stakeholders indicated that it was a difficult task for the client to bring the different interests together, the contractor themselves were at a distance from the stakeholders. One of the respondents did, however, state that he was aware of the conflicting interests that existed between, for example, the NS and GVB.

Client's perspective

When asked how the client estimated the various stakeholders, one of them indicated that they always knew which stakeholder to approach and they were always available for them. He further said: *"Depending on the person sitting there, whether he is decisive or not, whether he has a mandate or not, it determines success"*. He thinks that a requirements analysis would have helped the contractor to become well informed about the stakeholders interests and possible needs.

Furthermore, the 'not in my backyard' principle was mentioned. One of the respondents explained that the various managers of the station were happy with the development of the station, but at the same time they were not happy with the work involved. The concerns about this were included in the contract in the form of requirements, but according to him, the stakeholders need to be involved more directly so that they can explain their concerns.

Stakeholders' perspective

GVB

The respondent indicated that he felt that the contractor was well aware of his organization and also of the issues that had previously occurred in the preliminary phase. During the interview he said: *"I have quite a few acquaintances there, in that project. So that also saves a lot of explanation, they know how I feel about the project, they know how I react. And that makes it a bit easier for me"*. Even though he also said: *"My employer makes money by transporting passengers and not by standing still for some construction project. And a lot of techies don't want to understand that"*. He seems to care whether the

people at the contractor and client are aware of his organization and thinks this is very person-dependent.

NS Stations
The respondent indicated that ProRail and NS are organizations that often come across each other in infrastructure projects, which means that they are well aware of each other's interests. In this project too, where ProRail is part of the client's organization, he believes there is room to express each other's interests and wishes. However, in his opinion, that was more difficult with the contractor. He gave three reasons for this. Firstly, in his opinion the requirements in the contract were clearly described, but the underlying interests are not conveyed very clearly. The second reason is that ProRail (an organization with different interests) was part of the client organization and therefore the interests of NS were not always correctly conveyed. The third reason is that, in his opinion, the contractor had little experience with station projects. However, he indicated that he never saw it as an obstacle that the contractor was not exactly aware of their organization, *"if I can explain it in ten minutes to you, I can do it there too"*.

Conclusion
The respondents of the contractor told that they had not made assessments of the stakeholders. The reason seems to be that the contractor and client were at a distance from each other and therefore with the stakeholders as well, because the client maintained contact with the stakeholders. Although one of the contractor's respondents indicated that the idea is that the requirements provide information about the wishes of the stakeholders, a stakeholder was not convinced that the requirements provide sufficient information about their underlying interests.

The various respondents mentioned the importance of knowing each other, and described some tools that can contribute to this. One of the contractor's respondents sees the advantage of adding someone from the stakeholder relationship management department to the design team, as they do estimate the stakeholders. Furthermore, a requirement analysis is seen as a tool to get more informed about the stakeholders. But a real analysis to estimate the stakeholders does not seem necessary in the V&V process of the design phase.

5.1.3.3 Involving stakeholders in the decision-making
Stakeholders were only involved in making decisions when there were issues at play or when amendments to the contract were initiated. The respondents indicated that, in principle, the contractor went through the design process themselves and made the design choices. They explained that if there were any uncertainties about certain requirements, the contractor discussed them with the client in the various design meetings. If the client could not provide clarification, then the client went to the stakeholders to clarify the requirement and discussed the results with the contractor. The client thus functioned as an intermediary between the contractor and stakeholders, and there was little joint consultation with all parties (illustrated by the example of the vertical point of ascent in section 5.1.3.1). Furthermore, the stakeholders were only informed about the design choices made at the end of each design phase and were then able to comment. However, this seems to be insufficient. The following sections show the speculations of the various parties on this part of SM and indicate possible areas for improvement.

Contractor's perspective
Both respondents have the opinion that the stakeholders were not sufficiently included in the decision-making about design choices. They believe that stakeholders should have been more involved, as one of them said: *"I would have liked the stakeholders to have more say about how you could solve certain things practically. That we could have coordinated more with them instead of with the client. That really was an inhibiting effect"*.

As mentioned, stakeholders were only involved in the decision-making when there were issues or amendments to the contract. However, the respondents mentioned some bad examples of this. Once,

when the contractor did had the opportunity to coordinate a part of the design with a stakeholder, the costs got completely out of hand because there was no one at the meetings to keep an eye on the contract. The stakeholder is very satisfied with the result, but huge discussions arose about the financial consequences. Another example about the vertical point of ascent, already mentioned in section 5.1.3.1, illustrated that the stakeholders were involved too individually.

Client's perspective

One of the respondents indicated that if a requirement is clearly described, the contractor does not need to involve the client and stakeholders. If different interests had to be weighed against each other, both respondents see a trade-off matrix as the solution. Given the amount of work involved with this method, the respondents understand that the contractor was not always applying this method.

One of the respondents explained that if the contractor would have been transparent and would have indicated which requirements they had difficulties with, the client could have involved the right stakeholders. He indicated that this generally went well if a single stakeholder had to be involved, but issues involving multiple stakeholders were not properly organized. As one of them said: *"I don't know how, but we really should have done that. Bringing multiple stakeholders together, organising that you get multiple stakeholders around the table about a particular file. And that you agree, if possible, who is the most important stakeholder ".* So he believes that it will be helpful if it is known which interest prevails over another. In his view, this would make it easier to make decisions, since an official client is generally not strong at making decisions due to political pressure.

Stakeholders' perspective

GVB

The respondent is of the opinion that his organization is always involved in decisions in time as long as something has not been made yet. He believes that it is primarily important for the contractor and client to involve their organization at an early stage to avoid expensive adjustments.

NS Stations

The respondent noticed that in the preliminary phase of the project there was much greater equality between the different parties in terms of decision-making. In the preliminary phase, it was jointly decided how the station should function and what it would require. In principle, he believes it is a good thing that there is less equality in the design phase, *"because we absolutely have a different view of how a station should function than ProRail does and therefore do not always have the same interests"*.

The respondent indicated that the degree of involvement of his organization in the decision-making of design choices has changed considerably during the design phase. During the first period of the design phase, his organization was only involved in the review moments. Added to that, he said: *"We may have been a bit lucky there, although it was no luck for the project. But that preliminary design was redone several times, which meant that adjustments could be made"*. During the final design phase, his organization was involved in making the design choices, *"It costs us a lot of time, but I think it is important and of added value "*.

Conclusion

Involving other parties in the decision-making in the design phase was done by the contractor based on issues that arose, in which they first contacted the client and in some cases the client contacted the stakeholders. Both the client and the contractor are satisfied with this method, although the contractor felt that stakeholders should be involved more often. When making decisions with stakeholders, there is a risk of deviation from the contract. That is why, according to both contractor and client, someone must monitor the contract properly.

It turns out that there were difficulties with issues that affected multiple stakeholders. The respondents of the contractor think that joint sessions should have been organized earlier for such matters. The client thinks that trade-off matrices are a good tool for weighing up different interests, although they also recognize that this is a lot of work for the contractor. One of the client's respondents thinks that it would be helpful if it is known which stakeholder has the most influence.

Normally, when there were no issues, stakeholders were only involved in the review moments at the end of a design phase. Although one of the stakeholders stated that they are involved in time as long as they are involved before something is made, the other stakeholder was pleased to see that they were increasingly becoming more involved. It seems best for every party if stakeholders are involved earlier and more often when making decisions in the design process or if the contractor present decisions made during the process frequently.

5.1.3.4 Continuously interacting with stakeholders

Little attention has been paid to this part of SM. The distance between the client and contractor, certainly at the beginning of the design phase, has caused that the stakeholders were not involved enough. The stakeholders were only involved when issues were at play and otherwise only informed about the design choices through the review moments at the end of each design phase. Due to the absence of activities to set common goals in the beginning of the design phase, such as a requirements analysis, many questions were raised from the stakeholders about the design. For this reason, the client scheduled meetings with the stakeholders to keep them informed every two weeks[9]. These meetings were without the presence of the contractor, so a separated way of communication took place. The stakeholders, however, wanted to be better involved. Because the stakeholders were not properly involved during the process, they felt that they were not heard. According to most respondents, this was the reason why it took four times before the preliminary design was accepted. This section elaborates this in more detail and presents the possible areas for improvement mentioned by the respondents.

Contractor's perspective

Both the client and the contractor feared that the stakeholders would come up with additional wishes to the contract and that it would have financial consequences for them. One of the respondents sees this fear as the reason why the client did not allow them to have direct contact with the stakeholders. He explained that in some cases there was contact with the stakeholders, but when decisions had to be made, there was separate contact between either the client and the relevant stakeholder or the client and the contractor. The other respondent feels that additional wishes (or amendments) to the contract have not always been discussed openly and honestly.

Although one of the respondents believed that support was *"just there, because the stakeholders understood that a station had to be built"*, both respondents thought that it would be good to organize more joint sessions. One of them had put forward several ideas that in his view would help in those joint sessions. In order to allay the fear of possible undiscussed financial consequences, he believes it would be good if someone was present to ensure that the rules of the contract are strictly followed at all times. Furthermore, he thinks that more attention should be paid to, what he called, the 'soft' side of the project. With that, he believes that it would be good if someone from the stakeholder relationship department would be present in the design meeting. In his view, that person can organize design presentations (for example supported with a BIM model) to keep the stakeholders up to date about the design. Furthermore, that person can ensure that stakeholders feel heard by recording every wish they have and analyze if that wish can be included in the design by starting an open discussion with the client about the possible financial consequences.

[9] None of the interviewed stakeholders participated in these meetings, so probably these meetings were only held with stakeholders who had questions.

Client's perspective

According to the respondents, the contractor worked too individualistic in the design phase, especially in the beginning. Only if the contractor was facing issues, they involved the client and sometimes they asked if a stakeholder could join. One of the respondents indicated that it would have been good if the contractor had interwoven the V&V process with the design process. If that had been done, it would be checked for each design step whether the devised solution meets the applicable requirements and the stakeholders would be involved to validate whether it leads to the right result.

There was a so-called integral design meeting[10] every four weeks, attended by the client, contractor, and stakeholders. The status of the design was presented in these meetings, but according to one of the respondents that could have been done better. In his opinion, too much attention was paid to problems in those meetings. He believes that you should proudly present the status of the design, by which he means that attention should be paid to the overall picture, and topics that are going well should also be discussed. By doing this, in his view, stakeholders would become more enthusiastic and involved in the project. As he said: *"Continue to involve, inform and present. Even if there is nothing to report, go to the stakeholder and show what you have done. I think we often go wrong on that, we were too busy with problems"*.

One of the respondents saw the review moments also as a contribution to create and maintain support among stakeholders, *"ZuidPlus submitted the preliminary design four times, so we also had to review four times together with our stakeholders. We had a very good process between us and our stakeholders, so that the reviews were carried out in a very structured way. As a result, we have a lot of support from our stakeholders, up to the present day "*. The other respondent also felt that the support of the stakeholders was properly secured, they also discussed their working method internally.

Stakeholders' perspective

GVB

The respondent indicated that his organization was not involved in the design process frequently. When an issue arose, they became involved and agreed with the client and contractor how often they would interact with each other. He sees it as his responsibility as well to ensure that nothing is designed that is undesirable for his organization. He explained that he goes very far in this and takes an active stance to ensure that their interests are conveyed, although he realizes that they cannot just come up with all kinds of contract amendments.

One of the reasons he believes an active attitude is necessary is because of the somewhat conflicting interests between his organization and the interests of the train operators (NS and ProRail). He sees it as a risk that the interests of the train operators prevail over the interests of his organization because some organizations are part of the client's organization. When asked whether these kinds of interests are discussed during the meetings with the client and contractor, he responds with: *"It is not part of a construction project, but I am the one who always brings it up"*.

The respondent indicated that there is no consistent quality of how his organization was involved in the design process, *"that varies from day to day and also depends on the sub-project leader who is responsible at that time"*. He does see an improvement compared to the preliminary phase and believes that the contractor has succeeded in creating support from his organization for the project. As he said: *"As long as they communicate honestly"*.

NS Stations

The distance between the parties at the start of the design phase logically meant that his organization was less involved in the project. He felt that, during the design phase, it changed from a formal V&V process to a more integrated V&V process in the design process. As he explained: "*Where the client*

[10] Only mentioned by one respondent of the client.

first said: "Here is the design, you have two weeks to review." They went in a number of steps, at the end of preliminary design phase or beginning final design phase, much more to sessions where specific themes were discussed". Because there were more design phases than planned, the respondent had the feeling that his organization was also becoming more connected.

The respondent thinks that a good mode has now emerged where joint sessions are organized in which the requirements are actually compared to the design solutions. Added to that he said: *"The flexibility to reinterpret or reformulate a requirement or to let a requirement go is much greater"*. In the future, he would like to see his organization being structurally involved in the design process from the start. He believes it is always good for a stakeholder to be closely involved in the design process, and also sees a responsibility for the stakeholder: *"What matters is that we as a stakeholder are consistent in what we say"*.

The respondent thinks that to create and maintain support from the stakeholders, it works well when the designers (the contractor) give a presentation before the review moments to all stakeholders. In this way, the client can provide background information about the design choices and explain mutual relationships, so that there will be more understanding of the design. The respondent emphasized at the end that it is very important that he himself keeps his organization up to date to maintain support.

Conclusion

Several possible reasons are given for the large distance between the parties at the beginning of the design phase. One of these is the fear from both client and contractor for financial consequences of additional wishes from stakeholders with respect to the contract. The parties are afraid that possible financial consequences will remain undiscussed and will cause major surprises in the end. Another reason is that the contractor, according to the client, has not made an analysis of the requirements before they have started designing. Several respondents indicated that the V&V process was not integrated with the design process so that the design was not properly aligned with the requirements and there was no frequent communication with the other parties. As a result of this distance between the parties at the beginning of the design phase, little attention has been paid to this part of SM. The interviewed stakeholders, therefore, indicated that they themselves had to ensure that they were involved.

During the design phase, the distance between the parties decreased. The V&V process was more integrated and the parties jointly examined whether the design matched the requirements. The parties indicated that in the future they would like to have more joint sessions with all parties involved from the start. In order to create and maintain support from the parties, it seems particularly important to keep stakeholders structurally informed about the design and to provide background information on design choices and changes. Several respondents believe that a design presentation prior to the review moments makes a major contribution. This presentation should pay more attention to the overall picture and not just focus on the problems of the project. One of the contractor's respondents believes that it will be good to involve someone from the stakeholder relationship department in the design process. In his view, this person can organize the design presentations and can ensure that stakeholders feel heard by recording every wish they have and analyze if that wish can be included in the design by starting an open discussion with the client about the possible financial consequences. He also thinks that it is important to involve someone in the design process who ensures that the rules of the contract are strictly followed at all times, this can allay the fear of unwanted financial surprises.

5.1.3.5 Conclusion case public transport terminal

In this sub-project, the respondents of the interviews observed a great distance between the client and contractor in the design phase, especially in the beginning. Because of this distance, the stakeholders were not really involved in the design process, as the client coordinated the design with the stakeholders while the contractor made the design. Looking at the four SM groups, little SM was carried out during the design process. The conclusions of case 2 are detailed in Table 3 per SM group.

Table 3: Conclusions of case 2 per SM group

Part of SM	Conclusions
Setting goals together	It can be concluded that little has been invested in this part of SM. No attention has been paid to get common understanding of the requirements at the beginning of the design phase when the contractor became involved in the project. As a result, the designers were not well aware of the underlying interests and possible needs and concerns of the stakeholders.
Assessing stakeholders	The persons involved in the design process of both the client and the contractor have not made an assessment of the stakeholders. However, the stakeholders do not seem to be bothered about this. One had the feeling that the client and contractor were well aware of his organization and the other did not think it was a problem that the contractor was not exactly aware of his organization, as long as he was given the opportunity to clarify the interests of his party.
Involving stakeholders in the decision-making	The involvement of stakeholders in the decision-making process changed during the design phase. In the beginning, stakeholders were only involved based on design issues or at the end of each design phase when reviewing the design. Both contractor and stakeholders found this insufficient. Things got better when stakeholders were also involved in design meetings.
Continuously interacting with stakeholders	Stakeholders were not involved in the design process frequently, but were only involved based on issues and, at the end of each design phase, when reviewing the design. However, stakeholders have indicated that they consider this insufficient and would like to be more involved. It was also pointed out that there was not always open communication because both the client and the contractor feared financial surprises.

It seems that the parties need to invest more time in understanding each other. In the beginning of the design phase, more understanding will have to be gained for the requirements by analyzing the underlying interests, concerns and needs. Several respondents believe that by conducting a requirement analysis, parties could become aware of the underlying interests and concerns behind the requirements and thus get a better picture of the purpose of the requirements. In addition, this provides insight into each other's points of view, so this could contribute to closer cooperation between the parties from the beginning. Moreover, efforts must be made to ensure a greater understanding of the design by involving stakeholders in the thinking process when making design choices. According to the respondents, this can be achieved by integrating the V&V process with the design process and structurally involving stakeholders in the design choices. Furthermore, it helps if the contractor gives a design presentation to all stakeholders just before the review moments, in which they explain the design choices made and the mutual relationships.

One of the respondents sees an important role within the design process for someone from the stakeholder relationship department and someone from the contract management department. In his view, the person from the stakeholder relationship department can take care of the, as he called, 'soft side' of the design process. Within this department, they did make an assessment of stakeholders so this person will be more aware of the stakeholders. Furthermore, he thinks that this person can organize the design presentations and ensure that stakeholders feel heard by recording every wish they have and analyze if that wish can be included in the design by starting an open discussion with the client about the possible financial consequences. The person from the contract management department should ensure that the contract is strictly adhered to at all times.

5.2 The ViA15 project

5.2.1 Project description

The roads around Arnhem are getting busier, which leads to congestion problems. Therefore, the central government and the province of Gelderland have decided to solve this problem by extending the A15 and widening the A12 and A15. From the junction at Ressen, the A15 will be extended as a highway with two-by-two lanes to the A12 between Duiven and Zevenaar. The highway crosses the Pannerdensch channel with a bridge. The measures are carried out under the project name ViA15. The new A15 with a junction to the A12 also creates a direct connection between the port of Rotterdam and Germany (Rijkswaterstaat, 2020). An amount of 570 million euros has been reserved for these activities. That is only for the realization of the project, the maintenance work doubles this contract sum (Koenen, 2020).

Figure 7: Project scope ViA15 (Rijkswaterstaat, 2020).

Project ViA15 is a large project with a lot of impact on the environment. Rijkswaterstaat[11], the client of this project, has therefore selected GelreGroen as the contractor because they planned to invest a lot in satisfying the surrounding. GelreGroen is a consortium consisting of BESIX, Dura Vermeer, HOCHTIEF, Van Oord, and John Laing[12]. Rijkswaterstaat and GelreGroen have the vision to properly inform the surrounding, to involve them closely in the developments of the project and to try to prevent or reduce nuisance (Rijkswaterstaat, 2020).

In the ViA15 project, implementation agreements (‘uitvoeringsovereenkomsten’ in Dutch) are used, in these agreements the requirements are laid down per stakeholders at an abstract level. This concerns requirements for objects that come into the operation of the relevant stakeholders after completion of the project. These implementation agreements are part of the contract with the contractor. Before the contractor starts the realization of an object, it must be demonstrated to the stakeholders that the design meets the requirements of the stakeholders (Massom, 2018). These implementation agreements make it very clear which requirement originates from which stakeholder.

The contract of the ViA15 project was awarded to GelreGroen in 2019, and then entered the design phase. As explained in section 2.3, the case studies focus on the design phases. The design phase is divided into a preliminary design phase, final design phase and an implementation design phase. The preliminary design was approved in one go by the client and stakeholders, now the project is in the final design phase. GelreGroen has divided the project into four areas, one of which is being investigated as a case study. The areas are divided based on location and large structures.

[11] When in case 3 reference is made to 'the client', this organization is meant.
[12] When in case 3 reference is made to 'the contractor', this consortium is meant.

5.2.2 Case 3: Subarea four

Subarea four is located in the north-eastern part of the project area. Part of this area is managed by the municipality of Zevenaar, the contractor therefore signed an implementation agreement with them. Structure 59 is located in this subarea, a structure that was discussed during the interviews. Structure 59 is a flyover with a motorway and a railway underneath. The motorway is operated by the municipality of Zevenaar and the railway is operated by ProRail. Large outlet centers will be built close to Structure 59, making it important for the municipality of Zevenaar to get a good connection to it. ProRail has an interest in Structure 59 because they have plans to expand their railway. Both the municipality of Zevenaar and ProRail came up with additional wishes to the contract during the preliminary design phase. This topic was discussed during the interviews.

In order to investigate how stakeholders are involved in the step from contract requirement to design choice in the V&V process, interviews are held with various people of the client and contractor who were responsible for the design and with someone from an organization which are seen as a stakeholder in this project. This comes down to the following respondents:

- From the contractor[12]:
  - The integral design manager of subarea four. He is responsible for all civil engineering related topics of subarea four, including structure 59.
- From the client[11]:
  - The project leader administrative environment. He was present at all design meetings and on behalf of the client responsible for coordination with stakeholders.
  - The stakeholder relationship manager. She was not involved in the design meetings but helped the project leader administrative environment to maintain relationships with stakeholders.
- From the stakeholders:
  - The process manager infrastructure of municipality Zevenaar.

5.2.2.1 Setting goals together

In this sub-project, much attention has been paid to this part of SM. First of all, during the tender phase, there already were meetings in which the potential contractors could ask questions to the client and sometimes to the stakeholders in order to understand each other's point of view. Thereafter, as soon as the contractor won the contract, various start-up activities were organized. First, there was a meeting only with the contractor and client, which was followed by a meeting where all the stakeholders were invited as well. At this second start-up activity, the contractor presented their global project plans and the stakeholders had the opportunity to ask questions and raise concerns. These start-up activities ensured that the parties got to know each other, the stakeholders got a first idea of the design and the contractor became aware of the interests of the stakeholders. After these start-up activities, the contractor conducted multiple sessions with the client and stakeholders together as part of their requirement analysis. During these sessions, they discussed with the client how requirements should be interpreted per theme, and involved stakeholders when they could not work it out together. The following sections describe the different perspectives on the previously mentioned activities to set common goals.

Contractor's perspective

According to the respondent, a lot of attention is paid to the requirements analysis, in which agreements were recorded properly. In order to perform a successful V&V of a requirement that comes from a stakeholder, he believes that: "*You have to know what the question behind the requirement is: Why did an operator draw up this requirement? What's behind that?*". He explained that a requirement could be that certain guidelines must be met, these are often general guidelines, so not specifically written for the project. Then it is useful to agree with the end operator which parts of those guidelines actually apply for this specific project. He believes that the requirements analysis has brought the parties closer

together and ensured that the parties involved worked towards a common goal from the start. Furthermore, he indicated that each design phase is concluded with a review moment during which stakeholders provide their comments. He sees the comments of the stakeholders as "*a shared interest in making a good follow-up*", by this he means that they use the comments of the stakeholders as a starting point at the beginning of each design phase.

In his view, verification plans should be shared with the client and stakeholders at the start of each design phase, stating how the contractor intends to demonstrate how they meet the requirements in the particular design phase. But, this has not be done in the preliminary design phase. By sharing these documents and getting agreements on these, the contractor would work from an agreed starting point.

Client's perspective
Both respondents are satisfied with how the contractor started the design phase with a requirements analysis. One said: "*Requirements that were still unclear were discussed per stakeholder so that a validation took place at an early stage*". In this way, common goals are set at the beginning of the design phase. The aim was to discuss the interests as early as possible, although one of the respondents indicated that the interests mainly become clear from each other when friction arises or threatens to arise. As an example, she mentioned a design for a structure for which the water board did not grant a permit because it did not meet their requirements. In a session with the client, contractor, and the water board, they then started to find out what the interests and concerns of the water board were. Then they explained what, in their eyes, was not clearly reflected in the design and the contractor could continue with that.

Stakeholder's perspective
The respondent was very satisfied that the contractor had already contacted her organization during the tender phase to introduce themselves and discuss their global plans. Subsequently, when the contract was awarded, her organization, together with the contractor and client, went to see what they needed from each other and they jointly discussed the plans for the design phase. She said: "*I can say nothing more than that it was handled flexible and open-minded*". With that, she meant that the contractor and client discussed common goals with her organization at the beginning of the design phase and were open-minded to their interests, and were flexible if they suggested something.

Conclusion
As mentioned, the parties paid much attention to this part of SM. Every party was satisfied with this and believed that this had a positive contribution to the V&V process. The contact between the parties during the tender phase seemed to be a good start and the various activities at the beginning of the design phase helped to have commonly agreed goals while taking each other's interests into account. One of these activities, mentioned by each respondent, is the executed requirements analysis.

5.2.2.2 Assessing stakeholders
At the beginning of the design phase, the contractor put a lot of effort to get informed about the stakeholders and the client helped them with this. After the contract award, the client informed the contractor about the possible issues, needs, and concerns of the stakeholders in various ways. For example, by handing over the stakeholder files that they drew up in the preliminary phase. In addition, various memos were sent with points that they believe require attention when it comes to stakeholders. In order to properly convey these different files, they held various presentations in which the client informed the contractor about the stakeholders. Furthermore, the contractor's stakeholder relationship department made analyses of the surrounding with the related stakeholders. Someone from this department was closely involved in the design process, so there was always someone present in the design meetings who was well informed about the stakeholders.

So the client tried to convey the information about the stakeholders, they had gained during the preliminary phase, to the contractor and the contractor themselves also took actions to assess the

stakeholders. These activities performed well, because the interviewed stakeholder felt that the client and contractor were well aware of the interests and concerns of her organization.

Contractor's perspective
The respondent, an integral design manager, is not very aware of the stakeholder analyses but indicated that their stakeholder relationship manager is always present at the design meetings with the stakeholders. Furthermore, he believes that the requirement analysis helped to get informed about the stakeholders, as he said: "*then you analyze together what the question was behind the question at each requirement the stakeholders have written down*".

Client's perspective
Due to the specialist meetings during the tender phase, the various parties have already become somewhat aware of each other's point of view. One of the respondents indicated that he noticed that the contractor was mainly aware of the stakeholders with whom they had many conversations, but they were less informed about others.

Stakeholder's perspective
The respondent explained that a project with such a large scale is not common for a municipality of their size. For this reason, her organization has a great need for advice and guidance, but in her eyes, the client realized this too little in the preliminary phase. For example, her organization had a difficult task in drawing up functional requirements when they were involved in drawing up the implementation agreements. In addition, they would have liked to be better informed about the course of the process and the meaning of the steps to be taken, so that they could have kept better control of the project. Furthermore, she noticed a difference in interest as the client was more focused on a rapid realization of the project and her organization was more focused on keeping the surroundings satisfied. She understands this difference in interest, but her organization felt that their interests were being somewhat neglected. Therefore, her organization sought collaboration with other municipalities in the preliminary phase and notices that they now have a greater voice. In her view, an additional advantage of working with other municipalities is that they can discuss matters that are unknown to them.

During the design phase, she feels that the contractor and client are well aware of the interests and concerns of her organization. For her municipality, for example, it is important that Structure 59 is realized as quickly as possible and she has the feeling that the contractor is doing everything he can to achieve that.

Conclusion
The contractor and client worked together a lot at the beginning of the design phase to make a correct assessment of the stakeholders. Although the interviewed stakeholder felt that they were not properly heard and therefore sought cooperation with other parties in the preliminary phase, in the design phase she did get the feeling that the client and contractor were well aware of her organization. The conclusion could be that the various activities that have been carried out have worked.

5.2.2.3 Involving stakeholders in the decision-making
In general, the contractor makes the design choices and informs the other parties accordingly. Although in practice, input from the stakeholders is incorporated in the design, the respondents explained that it is not the case that the stakeholders, client, and contractor are making the design together. However, the client and stakeholders are given the opportunity to reject design choices if they do not meet the requirements during the design meetings and at the end of each design phase through reviews. If stakeholders want something that deviates from the contract, they must arrange this via the client using a dedicated process. This section describes the different perspectives on the involvement of stakeholders in making decisions.

Contractor's perspective
The respondent mentioned two ways in which stakeholders are involved in the decision-making in the design process: the two weekly design meetings and the review moments at the end of each design phase. According to him, in the design meetings, the stakeholders are both informed about the design choices made and they are actually involved in making design choices. He said: "*In all areas, we ensure that we have design interactions. In these interactions we discuss in which direction we are going and check what is expected. That is an important one."*. He cites Structure 59 as an example where it became clear during the design meetings that stakeholders wanted some adjustments to the design, so then solutions were sought together (with the client, contractor, and stakeholders). He sees a major role for the contract managers of the client and contractor in making decisions about requirements for the design. They ultimately determine whether something is an amendment to the contract or not. The contract managers are not involved in the design meetings, but he states that both the client and the contractor are responsible for monitoring the scope of the contract.

At the validation moments at the end of each design phase, the contractor has the contractual obligation to get a signature from each stakeholder on the design. The contractor also receives a validation form from each stakeholder in which they state their main points for attention (possible concerns). These points for attention are then included in the next design phase. He explained: *"These validations are mainly to make the client and stakeholders able to check and to steer, insofar as this is desirable. But that they can, in any case, continue to check and stay informed"*.

Client's perspective
Both respondents are of the opinion that it is not needed to involve stakeholders in making design choices. However, one of the respondents indicated that the stakeholders, and the client as well, would like to be more informed about the reasoning behind the design choices made. To weigh up different interests, the contractor sometimes chooses to create a trade-off matrix and present it to the client and stakeholders. However, according to one of the respondents, the contractor is not consistent in this, sometimes they do and sometimes they do not create a trade-off matrix.

Stakeholder's perspective
According to the respondent, it is fine that the design choices are made by the contractor, as long as the interests of her organization are properly taken into account in the design and they are kept well informed. The contractor, therefore, informs her organization during the two-weekly design meetings. During these meetings, her organization has the opportunity to comment, after which a solution is always sought in her eyes. In addition, her organization is involved in reviewing the design at the end of each design phase. During the review moments, her organization is asked to approve the design and has the opportunity to comment.

Conclusion
In principle, decisions in the design process are made by the contractor. Although the respondents of each party indicated that input from stakeholders is incorporated in the design. The respondents of the client and stakeholder were positive about this way of involvement, as long as they are kept well informed about design choices made and the reasoning for arriving at those choices. The contractor uses the two weekly design meetings and the review moments at the end of each design phase for this. In this way, they can indicate when they disagree with something and the parties can look for solutions together. According to the client's respondents, the contractor should provide a little more information about the reasoning for arriving at some design choices. In their view, they could use trade-off matrices for this.

5.2.2.4 Continuously interacting with stakeholders
In this sub-project, it is clear to see that the contractor and client do a lot to maintain and create support from stakeholders and help each other in various ways. The design meetings ensure that there is frequent contact with every party involved. In these design meetings, the parties have open discussion

about the design. Furthermore, there are frequent meetings to discuss the process and collaboration. Some employees of both the client and the contractor are participating in both the design meetings and the meetings about the process and collaboration to remain well informed about the relationships. This section describes how the interaction between the parties proceeds through the design phase from the different perspectives.

Contractor's perspective

In order to maintain support of the stakeholders, the respondent finds it important to continuously check whether stakeholders are satisfied with the product they will receive. In his view, this starts with a good requirements analysis and after that the two weekly design meetings are important. During the open discussions about the design, it is very important to monitor the scope of the contract. On the one hand, if a wish of the client or a stakeholder deviates from the contract, it must be pointed out that this must be done by means of an amendment. On the other hand, the client can point out to the contractor that everything stated in the contract must be made. As he said: *"The V&V process helps us with this so that we record that we have ultimately fulfilled our contract with our design"*.

Furthermore, he sees a major role for the contractor's stakeholder relationship manager to create and maintain support from stakeholders. It is therefore the strategy of the contractor to closely involve the stakeholder relationship manager in the design process. He said: "*The personal contact he has with the stakeholders, the coffee moments. Being open with each other, it is about the soft side instead of the hard side"*.

Client's perspective

Both respondents have indicated that there is regular contact between the client, contractor, and stakeholders together and believe that the cooperation between the parties in this project is very good. Although the client did not prescribe the frequency with which the contractor must have contact with the stakeholders, they did indicate which requirements are important to speak about regularly with the stakeholders.

In their view, it is good that the contractor takes the lead in coordinating the design with the stakeholders. One of them said: "*We can see that the contractor is really doing his best to work from the previous stakeholder validations and shape the design*". However, one of the respondents has the idea that the contractor does not always work structurally. In his opinion, it differs per stakeholder with what frequency is spoken and whether agreements are clearly recorded. This probably has to do with elements that have been put forward in the planning, but he does not always have insight into the meetings between the contractor and stakeholders. The client does have a contractual agreement with the contractor that they must be informed if the contractor enters into a meeting with a stakeholder. The client would like to hear feedback on this in the general consultation between the client and the contractor.

They also ensure that they participate in some meetings for different reasons. First, to monitor the contract. Second, to prevent design choices being made that are detrimental to them. Thirdly, to guarantee the integrality of the project, so that the contractor does not make design choices together with one stakeholder that is unfavorable for another stakeholder. And they like to keep abreast of the relationships between the different parties in order to avoid becoming involved when there already is a conflict. One indicated that she believes it is the role of the client to ensure that everyone understands each other. She cites an example where there was some friction between a stakeholder and the contractor, then she called the parties together to ensure that mutual understanding was restored. In her view, a project has no chance of success if there is no good cooperation between the various parties.

Despite the good cooperation, several points for improvement are still seen. For example, one of the respondents is of the opinion that the contractor does not always communicate openly about their interests, he does not know why. In his opinion, the contractor has the strategy to keep the client and stakeholders informed through presentations and does so without sending information in advance. But

some stakeholders have indicated that they would like to be informed thoroughly and in time so that they can prepare properly. That is therefore seen as a learning point from the first design phase.

Stakeholder's perspective

The respondent indicated to be quite satisfied with frequency of which her organization is involved in the design process and the open communication between the parties. She believes that the collaboration with the client has improved a lot compared to the preliminary phase. And is very positive about the two weekly design meetings with the contractor and client, in which, in her opinion, there is open communication. She feels that the contractor is really doing their best to stay informed about their interests and she is very satisfied with the contractor's stakeholder relationship manager with whom she is in contact. She notices that there is support for the project because of the way in which her organization is involved. For instance, she mentioned as an example that she indicated to the contractor that she wanted to involve her colleagues more in the project. The stakeholder relationship manager then organized an activity in which he went through the project area together with a number of people from her organization and explained the state of affairs.

However, she did mention a number of points for improvement for the client and contractor. She notices that there are fewer joint meetings together with other stakeholders in the design phase, while she found this a pleasant way of working in the preliminary phase. She is not familiar with the reason of the contractor to approach it in this way, but she suspects that the COVID-19 virus is related to it. Due to the more individualistic approach, she becomes less aware of the interests of other stakeholders and is of the opinion that it is more difficult to manage interfaces. She mentioned a provincial road as an example. In the preliminary phase, the province drew up a landscape development plan together with her organization. In the design phase, no more joint meetings were organized with the province anymore and the province suddenly came up with a completely different plan, without coordinating it with her organization. As a result, they suddenly had to adjust all their plans to the new plan of the province. Furthermore, she mentions once again that both the client and the contractor should be more aware that a project of this scale is not common for a municipality of their size. As a result, they do not realize how important it is for her organization to be informed about matters in a timely and thorough manner so that they can prepare themselves properly. Since her organization does not have all the knowledge and skills associated with a project like this, they sometimes have to hire specialists to participate in meetings on their behalf. However, they do not always get the time for this.

Conclusion

It can clearly be concluded that in this sub-project a lot of attention is paid to this part of SM. There is close cooperation between the parties and they have frequent contact. The client and contractor seem to help each other in maintaining and creating stakeholder support. Both feel the responsibility to monitor the contract and to record agreements that are made during the meetings they have with each other and the stakeholders. During these meetings, relationships between the parties are monitored and in case of friction, the parties are jointly brought together. The stakeholder relationship manager, who is involved in the design process, seems to play a major role in maintaining and creating support, as both the contractor and the stakeholder expressed themselves positively about his role.

However, the stakeholder and the client do see some areas for improvement. First, they want to be better informed about the reasoning of the contractor in arriving at the design choices. Prior to a presentation by the contractor, they would like to be informed in such a way that they can prepare themselves correctly. Furthermore, the stakeholder believes that joint meetings with other stakeholders work better in coordinating interfaces.

5.2.2.5 Conclusion case 3

In the V&V process of this sub-project, much attention seems to be paid to SM during the design phase. The conclusions of case 3 are detailed in Table 4 per SM group.

Table 4: Conclusions case 3 per SM group.

Part of SM	Conclusions
Setting goals together	In the beginning, a lot of time was invested in getting to know each other and setting goals together. This has had a positive effect as every party looked back on it with satisfaction. Activities that might have contributed were: specialistic meeting during the dialogue phase, a start-up presentation with all stakeholders and the requirement analysis.
Assessing stakeholders	While the stakeholder felt that the client was not well aware of them in the preliminary phase, this changed in the design phase when they felt that both the client and contractor were well aware of their interests and concerns. The client and contractor performed various activities from which they believe it contributed in making an assessment of stakeholders, which were: stakeholder files, various memo's, presentations about stakeholders' needs and concerns and the requirement analysis.
Involving stakeholders in the decision-making	Decisions in the design process are generally made by the contractor, the client and stakeholders are not so much involved. The client and stakeholders agree with that, as long as they are kept well informed about design choices made and the reasoning for arriving at those choices. Besides, they want to have the possibility to steer the process if design choices are made which are detrimental to them. The client and stakeholders seem to be given the opportunity to do so in the design meetings and during the review moments at the end of each design phase.
Continuously interacting with stakeholders	A lot of attention is paid to creating and maintaining the support of the stakeholders during the design phase and that also seems to be important. There is a lot of joint contact between the parties on various themes such as design and collaboration. The client and contractor each seem to feel their responsibility in maintaining relationships and safeguarding the contract and are supporting each other with that.

A great willingness to cooperate between the parties can be observed in every SM group in this sub-project. It seems that the parties are working closely together and have a lot of trust in each other. For example, both the client and the contractor mention the importance of monitoring the contract during contact with the stakeholders and trust each other in this.

From the interviews it can be concluded that not only attention has been paid purely to designing, but a lot of attention has also been paid to the soft side of the design process. The contractor has deliberately chosen to involve an stakeholder relationship manager in the design process and that seems to work out positively given the satisfaction of the stakeholder. The stakeholder relationship manager is the point of contact for the stakeholders and takes care of many activities that contribute to the various parts of SM.

6 Cross-case analysis

This chapter presents the role of SM in relation to the V&V process, which is done by comparing the three case studies on various themes. The previous chapter has shown how SM has been carried out in relation to the V&V process during the design phase in practice. In that chapter the importance of each core value of SM has not yet been investigated, this is presented as the first theme in section 6.1. As mentioned earlier, in LIP's it differs whether the client or the contractor takes on SM in relation to the V&V process. In section 6.2, this difference is analyzed by comparing the cases of the Zuidasdok project with the case of the ViA15 project with each other. During the case studies, it was noticed that it differs per case if processes related to the V&V of stakeholders' requirements are performed more interrelated or are kept more separate from each other, section 6.3 goes into more detail about this. Another finding is that the processes were sometimes formally set up and followed and sometimes there was a more informal approach, section 6.4 describes this difference. Section 6.5 provides the context within which the findings were found and describes the interpretations.

6.1 Importance of SM categories

The previous chapter reveals what is being done on SM in relation to the V&V process per core value of SM. From these results it may already be noted that not every core value appears to be equally important in relation to the V&V process. Therefore, by comparing the findings from each case study, this section shares insights on the importance of the performed core values of SM on the V&V process. Furthermore, the literature study into SM (Chapter 3) focusses on SM in LIP's in general and is not specific to the V&V process yet. To discuss the adaptive nature of the evaluation tool, it is interesting to compare the findings from the cases with the underlying literature of the tool.

Setting goals together

From every case and every perspective, it can be concluded that setting goals together appears to be an important value in relation to the V&V process. Firstly, it appears from the responses of the stakeholders. In case 1 and case 3, stakeholders spoke positively about the fact that a lot of attention has been paid to this category. A stakeholder's respondent of case 1, for example, indicated that the support from his organization was partly due to the fact that good investments had been made in the introduction at the beginning of the design phase, both the introduction to each other and the introduction to the project plans. According to this respondent, setting goals together ensures, among other things, that the purpose of the contract becomes clear. Although one of the stakeholders in case 2 indicated that he was involved on time as long as something had not yet been made, he did believe that it is useful for both the contractor and the client to come to agreements as early as possible. The other stakeholder in case 2 indicated that he would have liked to be involved from the beginning of the design phase and even thought that this was one of the reasons why the preliminary design was only accepted the fourth time. The respondents of the client and contractor also seem to consider setting goals together to be an important value of SM in relation to the V&V process. The respondents of the client and contractor from cases 1 and 3 are positive about the attention paid to setting goals together at the start of the design phase. Since requirements are interpretive, respondents indicate that it is important to get everyone on the same page from the start. The respondents of both the client and the contractor in case 2 believe that insufficient attention was paid to setting goals together in their case. In that case, stakeholders were approached too individually, which meant that no joint coordination took place, which led to major delays. In section 5.1.3.1 this is illustrated by means of an example.

The interviews show that the requirements analysis, in particular, makes an important contribution to determining common goals in relation to the V&V process. Respondents mentioned several advantages of a carefully executed requirement analysis. First of all, it brings parties closer together from the start. Secondly, the parties become more aware of the underlying interests and concerns behind the requirements and thus get a better picture of the purpose of the requirements. And, by jointly making the requirements SMART, it is ensured that parties work on common goals from the start. Table 5 shows per case what has been carried out to set goals together, Chapter 5 describes this in further detail.

Table 5: Performed activities to set goals together per case.

Case 1	Case 2	Case 3
Kick-off meeting	No activities were mentioned to set common goals	During tender phase, potential contractor had first contact with stakeholders to ask questions
Requirement analysis		Kick-off meeting
Contractor discussed at start of each design phase how they intended to implement the requirements		Various sessions with contractor, client and stakeholders to see what they needed from each other
		Requirement analysis

According to the studied literature, presented in Chapter 3, this core value of SM must set a joint project goal that must be known among all stakeholders while taking into account the different interests and possible needs and constraints to the project. The description that literature gives is very similar to what respondents find important in the cases, its only difference is that SM in relation to the V&V process must ensure that multiple common goals (the interpretation of the requirements) are set instead of one.

Assessing stakeholders

The findings of the case studies suggest that this value of SM is not important in relation to the V&V process during the design phase. Despite the fact that it differ per case what was done on this part of SM, the stakeholders in each case had the idea that both the client and the contractor were well aware of them during the design phase. There was one respondent from a stakeholder in case 2 who did not feel that the contractor was well informed about his organization, but did not see this as an obstacle. As he said: *"if I can explain it in ten minutes to you, I can do it there too"*. Several of the contractor's respondents indicated that they do not see the usefulness of formal stakeholder analyzes and made their assessment based on feelings and experience. The clients of the various cases generally did make stakeholder analyzes, but it differed whether and how they shared this information with the contractor. In case 1 and 2, the client did not share the stakeholder analyses with the contractor. It has been mentioned a number of times that the train of thoughts is that the requirements are partly formulated on the basis of these stakeholder analyzes and that the contractor is thus informed of the stakeholders. In case 3, the client did a lot to ensure that the contractor was well informed about the stakeholders, but whether this was really necessary is the question. Table 6 shows per case what has been carried out to get informed about the stakeholders, Chapter 5 describes this in further detail.

Table 6: Performed activities to get informed of the stakeholders per case.

Case 1	Case 2	Case 3
No analyses made by the contractor	No analyses made by the contractor	Contractor had stakeholder relationship manager involved in design meetings who made analyses of stakeholders
Analyses made by client, not shared with contractor but requirements are partly based on these analyses	Respondents of client did not mention analyses	Client made analyses and shared findings with contractor at start design phase
		Client has informed the contractor about stakeholders through: presentations, stakeholder files, memos

Although the case studies paint the picture that this core value is not important in relation to the V&V process, this conclusion must be viewed with a critical eye to understand its broader relevance.

Therefore it is meaningful to understand under what conditions *assessing stakeholders* does not appear to be important. Firstly, the starting point is decisive. Several respondents stated that the experience they already had with certain people or organizations was helpful for understanding each other. When people and parties have a lot of experience with each other, *assessing stakeholders* via formal analyzes is of course less necessary. Moreover, various respondents have indicated that the contract requirements are based on the stakeholder analyzes of the client in the preliminary phase, then it is of course decisive whether the interests are sufficiently safeguarded in these requirements. It also makes a difference whether the contractor has been informed from which stakeholder a requirement originates and whether a proper requirements analysis has been carried out. Furthermore, the degree of contact seems to play a role, making it more or less important to assess the stakeholders. One of the stakeholders' respondents cited the frequent meetings as a reason why he felt that the client and contractor were well aware of his organization. Another said that he did not see it as an obstacle that the contractor was not fully informed of his organization under condition that he had the opportunity to explain himself.

According to the studied literature, presented in Chapter 3, the contractor and client become informed about the stakeholders by first examining the capacity and willingness of the stakeholders to threaten or cooperate with the project team. Furthermore they must become aware of the coalitions that the stakeholders can form in order to influence the end-result in their favour and they must become aware of the conflicts between the stakeholders. From the cases it is concluded that this value of SM is not very important in relation to the V&V process. In case 3, for example, the stakeholder has sought cooperating with other stakeholders to have a greater influence, but neither the client nor the contractor seem to have concerned about this. This is probably because the literature describes general SM in LIP's and does not specifically focus on the V&V process. Stakeholders involved in the V&V process are stakeholders who already have long-term contact with the client in the preliminary phase and make indirect contractual agreements with the contractor. A contractor usually comes into contact with these stakeholders during the process or has already encountered these stakeholders in previous projects, so it may indeed be the case that formal analyses of the stakeholders are not necessary.

Involving stakeholders in the decision-making

Each case showed a similar approach in involving stakeholders in the decision-making of the V&V process, as shown in Table 7. Most of the respondents agreed with this level of involvement. In case 2, however, a respondent of the contractor believes that the stakeholders were insufficiently involved in the decision-making. This was probably due to the fact that the contractor and the stakeholders were not in direct contact with each other in that case. Section 6.2 discusses this in more detail. There are a number of comments to be made regarding the conclusion that stakeholders are currently sufficiently involved in the decision-making of the V&V process on the basis of these cases. First, the question is when is a stakeholder involved in the decision-making of the V&V process? Is that when they are involved in the design choices made by the contractor or when they are actually involved in making decisions? The latter is seen in this study as 'involved in decision-making'. Stakeholders, and the client as well, do not need to be more involved in the actual decision-making in the V&V process but find it especially important that they are well informed about the contractor's arguments to make decisions. It may be that in case 2 the arguments of the contractor were not properly communicated to the stakeholders. *Involving stakeholders in the decision-making* thus seems to have a lot to do with the fourth core value of SM. In addition, *involving stakeholders in decision-making* has common ground with the first core value. Several respondents explain that when goals are carefully set at the beginning that are known to everyone, less involvement is required during the process.

In addition to the review moments in which stakeholders actually take part in deciding whether a design is satisfactory or not, it seems important to properly inform stakeholders about the reasoning behind decisions. The design meetings during the process seem to be suitable for this. During these meetings, the design is discussed and the contractor can provide his reasoning to arrive at certain decisions. In case 3 it is even indicated that stakeholders during these meetings have the opportunity to participate

in decisions about the design and it is expected that this was also the case in case 1. In the second case, these design meetings were mainly kept separate between either the client and the stakeholders or the client and the contractor, which meant that the stakeholders became less involved in the decisions. Another way to inform stakeholders more about the reasoning behind decisions, is through a presentation prior to the review moments. This ensures that there is more understanding from the stakeholders for the decisions taken.

Table 7: Performed way of involving stakeholders in the decision-making of the V&V process per case.

Case 1	Case 2	Case 3
Based on unclarities in requirements, problems with designing or amendments to the contract	Based on unclarities in requirements, problems with designing or amendments to the contract	Based on unclarities in requirements, problems with designing or amendments to the contract
Review moments	Review moments	Review moments
		Two weekly design meetings[13]

According to the studied literature, presented in Chapter 3, the project team should use the knowledge they have previously acquired about the stakeholders in the decision-making to ensure that the common goal is achieved. In fact, this has been ensured because there is a joint agreement on the requirements and the contractor made his design choices based on these. Besides, in cases 1 and 3, the contractor used the agreements from the requirements analysis to make design choices. Furthermore, it is recommended from literature to determine correct strategies to involve stakeholders in the decision-making based on the previous assessment of the stakeholders and the coalitions and conflicts among them. From the case studies, it can be concluded that in practice the contractor does not involve stakeholders based on previous assessments.

Continuously interacting with stakeholders

From the case studies, it can be concluded that this appears to be an important value of SM in relation to the V&V process. In case 1 and 3, the respondents expressed themselves positive about the effort that has put in this part of SM. The respondents of the stakeholders in case 1 and 3 believe that, partly due to the frequent and open manner of communication, support was generated from their organizations. The respondents of both contractor and client from these cases are satisfied with the implementation of this part of SM as well. One of the contractor's respondents emphasized that the parties' insights change over time and that it is therefore important to stay on speaking terms intensively with the end operators. They also believe that this reduces the chance of unwanted surprises for all parties. For the contractor, it reduces the chance of an unexpected rejection at the review moments and for the stakeholders it reduces the chance that they will receive a design at the end of a design phase that they are dissatisfied with. In the second case, this probably resulted in the design having to be resubmitted four times. The stakeholders were insufficiently involved during the process and were surprised with the design when they had to review it.

The frequent design meetings appear to work well to create and maintain support from the stakeholders during the process. It differs how these design meetings were implemented at the analysed cases. From the case studies, some things can be said about the way in which these design meetings can probably best be carried out. The respondents have indicated that an open way of communication is very important during these meetings in the presence of the contractor, client and stakeholders. Furthermore, it was mentioned that it is important not only to focus on the problems that arise, but also to take time to reflect on the positive stories. Several respondents believed that joint meetings with multiple stakeholders is needed if an issue affects several parties.

[13] The reason that this is mentioned in case 3 and not in the other cases is that in this case it has been explicitly mentioned by respondents from each party that these meetings offer stakeholders the opportunity to participate in decisions.

Table 8: Performed way of interacting with stakeholders through the V&V process per case.

Case 1	Case 2	Case 3
Design meetings - Two weekly - In presence of contractor, client, and stakeholders - Interactive, open, agreements were recorded	Design meetings - Two weekly - In presence of client and stakeholders - Separated from contractor	Design meetings - Two weekly - In presence of contractor, client, and stakeholders - Interactive, open, agreements were recorded
Design workshops with 3D models	Integral design meetings[14] - Four weekly - In presence of client, contractor and stakeholders	Meetings about process and collaboration - In presence of client, contractor and stakeholders
		Excursions through the project area

The case studies show that SM in relation to the V&V process has many similarities in practice with the literature on this part of SM. Respondents have indicated that they find it important to check changes in stakeholders' influence and relationships and to promote a healthy relationship with them. They believe that by communicating and engaging stakeholders properly and frequently, it reduces the chance of unwanted surprises. Most respondents also mentioned the importance of recording agreements and ensuring that they are carried out. From the case studies it can be concluded that the more often stakeholders are involved during the process, the smoother the V&V process goes.

6.2 Client or contractor driven SM?

An important goal of this research is to study the difference between a client or a contractor who is coordinating the design with the stakeholders during the design phase. As described in Chapter 1 and Appendix B, the client has been in contact with the stakeholders for many years during the preliminary phase. The client uses the CRS procedure to arrive at jointly agreed requirements for the contract with the stakeholders. Given the relationship that the client has built up with the stakeholders, it can be an advantage to continue this collaboration during the design phase by having the client coordinate the design with the stakeholders. This was mentioned several times during the interviews. However, a big difference compared to the preliminary phase is that an extra party is involved in the project and that they are responsible for the design, namely the contractor. Since the contractor is the one who actually works on the design, it can also be advantageous if they coordinate the design with the stakeholders. To analyse this difference, a conscious choice was made to analyse cases within a LIP in which the client coordinates the design with the stakeholders (case 1 and 2 of Chapter 5), and a case within a LIP in which the contractor takes on this task (case 3 of Chapter 5).

Case 1 and 2 of project Zuidasdok are cases in which the client carries out SM in relation to the V&V process. The respondents of these cases are describing the client as an 'intermediary' between the contractor and stakeholders. As can be concluded from the findings of the interviews, this can turn out differently. Where every respondent is satisfied with a client who acts as an intermediary in case 1, in the second case, dissatisfaction is given to this method of collaboration. In addition to the advantage that a client has already built up a relationship with the stakeholders, in case 1 it is seen as a great advantage that the client can better monitor the contract. The respondents in case 1 believe that if the client has the first contact with the stakeholders, they can more easily check whether the wishes of stakeholders are possible within the scope of the contract. As a result, the client can first estimate possible financial consequences themselves before discussing these with the contractor and the contractor can focus on making the design. Although this advantage is also seen by respondents from case 2, it is mainly the disadvantages that are emphasized. In case 2, the contractor's respondents indicated that they did not enter into a dialogue with the stakeholders because the client coordinated the

[14] Only mentioned once by a respondent of the client

design with them. While the client is coordinating the design with the stakeholders in both cases, there are quite a few differences between the cases in the extent to which the parties work together.

Case 1 shows a close collaboration between the contractor and the client. The client is closely involved in the design process of the contractor and they jointly decide on stakeholder involvement during the process. One of the stakeholders even felt that the contractor was the one who arranged the coordination of the design with their organization. Since the client and the contractor had the common starting point to involve the stakeholders as much as possible, they came to few surprises at the review moments at the end of the design phases. Although SM was carried out by the client, this was done in consultation with the contractor. Due to this close collaboration, each party was well aware of the status of the design and of the relationships with the project and with each other.

In case 2, a great distance was felt between the stakeholders and the contractor. There was a very separate way of working. Either the client and the stakeholders had contact or the client and the contractor. According to the respondents, the contractor went to work very individually on the design and the client took on SM very individually. Because the contractor and client were very much 'minding their own business', a distance arose between these parties, which meant that the stakeholders also became at a large distance from the design process. As a result, stakeholders were not involved so it was not validated with stakeholders whether they agreed with the design choices that were made during the design process. Only at the end of each design phase, the stakeholders were asked to review the design. This resulted in unwanted surprises for the stakeholders, the client and the contractor. Both the client and the stakeholders were surprised with the design and wanted to see a lot of adjustments realized, which is why they rejected the design three times. As the stakeholders were not much involved during the process, this came as a surprise to the contractor.

Although the contractor in principle carries out the SM in relation to the V&V process in the third case, the respondents describe a high degree of collaboration between the contractor and client in coordinating the design with the stakeholders. For example, at the beginning of the design phase, the client extensively helped the contractor to get informed of the stakeholders. During the process, the client likes to stay informed of the conversations between the contractor and stakeholders. They even have a contractual agreement with the contractor which state that they always have to inform the client when they enter into a conversation with a stakeholder. The respondents of the client mention the advantage of their built-up relationship with the stakeholders and have given some examples of this, described in section 5.2.2.4. Furthermore, they see the advantage that they can keep a better eye on the contract if they remain involved at the discussions between the stakeholders and the contractor. Due to this close collaboration, the contractor is well informed about the stakeholders at the beginning and during the process they can easily ask the client to help when a conflict arises.

Table 9: Collaboration in coordinating the design

Case 1	Case 2	Case 3
Client who coordinates the design with the stakeholders	Client who coordinates the design with the stakeholders	Contractor who coordinates the design with the stakeholders
High level of collaboration between contractor and client	Low level of collaboration between contractor and client	High level of collaboration between contractor and client

On the basis of these three case studies, it can be concluded that there is no clear pattern of a contractor or a client who is carrying out the SM in relation to the V&V process, the degree of collaboration seems much more important. Both the contractor and the client have important resources that are required to coordinate the design with the stakeholders, the contractor has a better view of the design and the client has already built up a relationship with the stakeholders. Furthermore, they have a common interest in monitoring the contract. Consequently, it is the interest of both of them to enter into good cooperation in managing the stakeholders in relation to the V&V process so that their strengths can be combined.

6.3 Interrelated or separated processes?

In the case studies, a difference can be seen in the way in which processes are carried out in relation to the V&V of stakeholders' requirements. Where in cases 1 and 3 the processes are quite interrelated, the second case describes more separate processes. The design team of the contractor at case 1 chose to set up the processes for the V&V of the requirements themselves. The contractor made the general V&V project plan specific for the sub-project themselves and jointly ensured that this plan was followed. Besides, they adhered to a plan that described, among other things, how to deal with the client and stakeholders. So the same team of the contractor that worked on the design, set up and worked on the V&V and thought about how to get stakeholders involved in the process in the same time. Furthermore, they carried out a requirements analysis together with the client in order to clarify the requirements. And due to the close collaboration between the client and the contractor, the design was jointly coordinated with the stakeholders. In case 2, the processes were carried out much more separately. The design team carried out the V&V process themselves, but a separate department set up the V&V process. As a result, the members of the design team did the V&V of the requirements not jointly but individually. The SM in relation to the V&V process was also performed separate from the design process, by the client. As a result, the stakeholders were at a greater distance from the design process. The respondents in case 2 expressed their dissatisfaction about this and were in favor of interrelated processes. In the third case, the responsibility for coordinating the design with the stakeholders rested with the contractor who simultaneously carried out the V&V process and the related SM. During the design phase, all parties were involved and the processes related to the V&V of the requirements were very interrelated. The aforementioned findings are summarized in Table 10.

Table 10: Processes related to performing V&V of the requirements

Case 1	Case 2	Case 3
Interrelated processes	Separate processes	Interrelated processes
Satisfaction among respondents about this strategy	Dissatisfaction among respondents about this strategy	Satisfaction among respondents about this strategy

6.4 Formal or informal?

Another difference that can be observed in the various cases is the degree of formality. The first case shows a high degree of formality in which the design process is fully organized according to the SE principles. The contractor's respondents indicate that it is very important to ensure that all employees adhere to the plans. Respondents of contractor, client and stakeholders were all satisfied with this formal way of working. It is important to be aware of the context in which this formal way of working led to satisfaction among the respondents. First of all, it was remarkable to see that the respondent of the stakeholder was also fully aware of the SE principles. During the interviews, it emerged several times that the SE methodology is already deeply rooted in the world of installation technology. As a result, there was common understanding of the process to be followed. Another point to be aware of is that case 1 was a case of low complexity with regard to stakeholders. Firstly, this case involved fewer stakeholders, secondly, the case consisted of fewer disciplines and therefore fewer different stakeholders, and thirdly, the stakeholders had experience with these types of projects.

It is difficult to say whether a formal or an informal way of working was used in case 2. The case had a high complexity with regard to the stakeholders. The case involved many different disciplines with many and many different stakeholders. On the one hand, a formal strategy seemed to be used in which responsibilities were clearly divided. But the respondents did not speak so much about a structured process according to the SE principles and the large number of different stakeholders perhaps also asked more for an informally structured process.

The third case shows a high degree of informality. In addition to the design meetings, meetings were organized to discuss the process and collaboration. Various employees of both the client and the contractor attended both meetings so that they were kept well informed about the attitude of the

stakeholders towards the project and the mutual relationships. The respondents are satisfied with this informal way of working in this case. For the interviewed stakeholder, a project of this size is not a normal course of affairs and was satisfied that it was guided through the process in an informal way. The aforementioned findings are summarized in Table 11.

Table 11: Formality of V&V process

Case 1	Case 2	Case 3
Formal	-	Informal
Satisfaction among respondents about this strategy	-	Satisfaction among respondents about this strategy

6.5 Overview and interpretations

In order to better understand the previous described findings, this section outlines the context in which they were found and describe observed patterns. Table 12 presents an overview of the conditions in relation to the V&V process of the cases, the perceptions that the respondents had of the V&V process, the approaches to the V&V process, the performed SM in relation to the V&V process and the outcome of the V&V process in terms of progress and satisfaction.

	 Conditions of the project related to the V&V process	 Perceptions of the V&V process	 Approaches to the V&V process	 Performed attention to SM in relation to the V&V process	 Progress of and satisfaction with the process
Case 1 - Zuidasdok project	- Contract with contractor dissolved after preliminary design - One technical disciple - Client driven SM in relation to V&V process - SE deeply rooted in world of installation technology	- Common understanding according to the SE methodology	- High level of collaboration between client and contractor --- - Interrelated processes --- - High degree of formality	- Much to *setting goals together* - Not much to *assessing stakeholders* - Average to *involving stakeholders in the decision-making* - Much to *continuously interacting with stakeholders*	- Good progress - Satisfaction among all respondents
Case 2 - Zuidasdok project	- Contract with contractor dissolved after preliminary design - Multiple technical disciplines - Client driven SM in relation to V&V process	- Different understanding	- Low level of collaboration between client and contractor --- - Separate processes --- - Individual performed V&V	- No to *setting goals together* - Not much to *assessing stakeholders* - Average to *involving stakeholders in the decision-making* - Not much to *continuously interacting with stakeholders*	- Difficult course of process - Dissatisfaction among all respondents - Stakeholders indicated that they were insufficiently involved
Case 3 - ViA15 project	- Project in final design phase, preliminary design approved in one go - Multiple technical disciplines - Stakeholders have implementation agreements - Contractor driven SM in relation to V&V process	- Common understanding between client and contractor - Unexperienced stakeholder	- High level of collaboration between client and contractor --- - Interrelated processes --- - High degree of informality	- Much to *setting goals together* - Much to *assessing stakeholders* - Above average to *involving stakeholders in the decision-making* - Much to *continuously interacting with stakeholders*	- Good progress - Satisfaction among all respondents

Table 12: Overview of the findings from the cases

The ambiguity of the V&V process, which has already been introduced in Chapter 1, can be recognized from Table 12. That means that the case studies show that this ambiguity can be identified in practice. The ambiguity in the process could lie in the two V's. The first 'V' refers to verification, as defined in Chapter 1, verification is the confirmation by objective evidence that the specified requirements have been met. Objective evidence can be provided by systematically following the requirements. The second 'V' refers to validation, as defined in Chapter 1, validation is the confirmation by checking whether the design is in line with the intended use of the stakeholders. So, validation cannot be provided by objective evidence but requires a more process-oriented approach. From Table 12 it can be concluded that the first case involved an SE-driven V&V process and the third case involved an SM-driven V&V process. This seems logical given the context of both cases. The first case concerned one technical discipline and the respondents indicate that the SE methodology is deeply rooted in that discipline. Therefore, there was a great deal of clarity and equal understanding of the V&V process among the involved parties. In this context, going through the V&V process formally and strictly appears to be an appropriate and effective approach. While going through the V&V process according to the SE philosophy, there was also clear attention paid to SM during the process. Although the contractor was responsible for going through the V&V process and the client carried out the coordination of the design with the stakeholders, the parties involved kept each other well informed. There was a high degree of collaboration between the client and contractor and the processes were interrelated. A high degree of collaboration between the client and contractor was also found in the third case. Besides, the processes related to the V&V were interrelated. Yet, the context of the third case was very different and so was the approach to the V&V process. For example, before the project started, the stakeholder interviewed did not even know what a V&V process meant. Therefore, a more (informal) SM-driven V&V process seems to be appropriate and effective. The contractor is responsible for both going through the V&V process and the SM related to it. As a result, the stakeholders are closely involved in the V&V process. Although the first and third cases had a very different approach to the V&V process, both proved effective given the good progression and satisfaction of all respondents.

In the second case, poor progression of the V&V process was found and there was dissatisfaction about the process among the respondents. This case involved different technical disciplines and processes were carried out very separately. The contractor was responsible for going through the V&V process and the client for coordinating the design with the stakeholders. In this case, the parties were at a greater distance from each other, causing the parties were less informed by each other. Furthermore, at the contractor, a separate department was responsible for setting up the V&V process while at the same time the design team worked on the design and had to carry out the verifications and validations. The exact cause of the negative outcome of the V&V process cannot be said for certain, but these findings sketches a context where those involved did not come together properly. There does seem to be a clear connection between the stakeholders who indicated that they were insufficiently involved and the small amount of attention that was paid to SM.

This research has shown that there is ambiguity in the V&V process, sometimes one approach is more effective than another. By examining three cases, two patterns were identified, an SE-driven V&V process and an SM-driven V&V process. It is recognized that one approach does not exclude the other, but it is the challenge of finding the right balance. This research focused on SM and has therefore recognized properties of SM that seem necessary for coordinating the design with the stakeholders. The theoretical and practical recommendations of these properties are presented in Chapter 9.

7 Discussion

In this study, a theoretical framework is applied that has been obtained from literature (see Chapter 3). It was used to formulate interview questions to evaluate SM in relation to the V&V process. The questions were applied to three cases in which in-depth interviews were held with those involved in the V&V process of the contractor, client, and stakeholders.

In view of the validity of this research design, there are some points to note. With respect to the validity of this research design, there are some points to mention. First of all, due to a lack of scientific research into SM in relation to the V&V process specifically, the literature that is used is on general SM in LIP's. This research can therefore be seen as an exploratory study into the role of SM in relation to the V&V process. This gave the theoretical framework an adaptive character. Secondly, in terms of number, it may be debatable whether the findings of three cases can be generalized. On the other hand, the cases have been examined in great detail and, after comparing the findings of the cases, patterns can be clearly recognized. Thirdly, it is difficult to say with complete certainty what a particular respondent meant. As mentioned in chapter 1, there are many different views on what the V&V process entails. Because the respondents can have a different view of what the V&V process amounts to, there is a risk that they are not talking about the same process. However, this research has adhered to the presented definitions, which were also introduced to the respondents and thus reduced the chance of this.

The identified ambiguity of the V&V process is recognized in practice as well, where the contractor and client choose a more SE-driven approach or a more SM-driven approach. The context in which the process takes place determines which approach is more effective. As can be seen in Table 12, the contexts of the cases were quite different. While in the first case there was a shared understanding of what the V&V process entails, in the third case the V&V process was unknown to the stakeholder prior to project start. Logically, this requires a different approach. This finding is comparable to the previously described approaches of project management from the studies of Ruijter (2019), Sundaramurthy (2003), and Van der Voort, Koppenjan, ten Heuvelhof, Leijten, and Veeneman (2011). They describe two types of approaches in which one focuses on a system-oriented collaboration and the other on a process-oriented collaboration. When managing projects, a balance needs to be sought between the two. From the case studies it can be concluded that case 1 required a more system-oriented collaboration and that case 3 was better suited with a more process-oriented collaboration. These findings are confirming the research done by Ruijter (2019), Sundaramurthy (2003), and Van der Voort, Koppenjan, ten Heuvelhof, Leijten, and Veeneman (2011). In both the first and third case of this study, this was acted upon correctly and ensured a smooth coordination of the design with the stakeholders during the design phase. Case 2, however, is an example where the project team searched for an effective approach but failed to find one. In this case, the coordination of the design with the stakeholders became a laborious process in which there was not only substantive disagreement about the design, but the stakeholders also expressed their dissatisfaction with how they had been involved in the process. Several stakeholders reported that they were insufficiently involved. This resulted in the preliminary design having to be resubmitted three times.

In line with Hertogh (2010), the respondents of this research agreed that the characteristics of LIP's require interaction with stakeholders. Something that is not necessarily included in the V&V process that originates from SE (Hertogh & Westerveld, 2010). This research, into the role of SM in relation to the V&V process by using the obtained theoretical framework, has resulted in several new insights. This research has shown that SM can help the V&V process. All respondents share the opinion that SM is required for smooth coordination of the design with the stakeholders. Moreover, no example has been discovered where SM has a negative influence on the V&V process. Finally, in the three case studies, a positive correlation was found between the amount of SM performed and the progression and satisfaction with the V&V process.

SM seems to be able to help the V&V process in various ways. *Setting goals together* appears to be truly important in the V&V process of the design phase. This seems a logical finding given the fact that the contractor is a 'new' party in the design phase and will be responsible to verify and validate the design. It is then useful for the contractor to understand the intentions of the stakeholders and the client with regard to the requirements and for the stakeholders and the client it is helpful to know how the contractor intends to meet the requirements. As previously described in section 6.1, the proposed SM strategies from the literature study (Chapter 3) is consistent with the findings of this research concerning this first core value. This research thus confirms what is described in the reviewed literature. This research has also shown that *continuous interaction with stakeholders* during the process in an open way is very important to sustain support from the stakeholders, this is in line with the expectations from the studied literature. However, several respondents indicated that open communication with the stakeholders entails the risk of an intentional or unintended deviation from the contract without proper agreements about the possible consequences. Some of them see a role here for contract managers and believe that they should be involved in coordinating the design with stakeholders. However, the role that contract management can have in relation to the V&V process falls outside the scope of this study.

Assessing stakeholders is another core value that is examined during the case studies. Studied literature recommends analyses of stakeholders to examine their power, interest, and attitude (Mok, Shen, & Yang, 2014; Wesselink & Paul, 2015; Yang J. , Shen, Ho, Drew, & Chan, 2009). However, the cases show that this value of SM is not that important in relation to the V&V process during the design phase. This result may be explained by the fact that their studies focus on SM in LIP's in general and does not specifically focus on the V&V process during the design phase. Stakeholders involved in the V&V process during the design phase are mostly stakeholders who already have long-term contact with the client in the preliminary phase and make (in)direct contractual agreements with the contractor. For that reason, it does not always seem necessary to analyse the stakeholders at the beginning of the design phase. The reader should take into account that this study focuses on the design phase, therefore the evolution of the relationship between the client and the stakeholders from project inception has not been fully explored.

The third core value of SM is about *involving stakeholders in decision-making*. According to the studied literature, the project team should determine strategies based on former stakeholder analyses to assess the required degree of involvement in the decision-making. However, stakeholders related to the V&V process are involved in the decision-making process at the end of each design phase anyway through their contractual connection. Besides, it appears that stakeholders do not necessarily want to be more involved in the actual decision-making, but rather want to be thoroughly informed about the reasoning of the contractor in reaching decisions. In that way, they considered to the opportunity to steer the project in their desired direction. A number of respondents have indicated that trade-off matrices can be helpful in weighing up various interests. A finding that is comparable to the advice that Ignacollo et al. (2017) give. Ignaccolo et al. (2017) see visualizing a decision problem as helpful in participatory decision-making. By visualizing the decision problem, the preferences and opinions of the stakeholders can be captured. Multicriteria decision-making methods can help in structuring the problem with different points of view.

This research shows that good collaboration between the client, contractor and stakeholders is of great importance in going through the V&V process because it reduces the risk on unpleasant surprises resulting in delay, conflict and cost overrun. This research has shown how SM can contribute to improving the V&V process, which can be used in the future by both the contractor and the client in setting up the V&V process for the design phase.

8 Conclusion

This research sought an answer to the question: *"How can stakeholder management help to improve the verification and validation of the stakeholders' requirements during the design phase of large infrastructure projects?"*. To answer this question, qualitative research was conducted into the role of SM in relation to the V&V process during the design phase of LIP's. An answer to the main research is provided after elaborating on the three sub-questions.

What are critical factors to perform successful stakeholder management and how can these be recognized in practice?

CSF's to successful SM were identified through extensive literature research. Defining CSF's as "those activities and practices that should be addressed to ensure effective management of stakeholders" (Yang J. , Shen, Ho, Drew, & Chan, 2009). Given the lack of research specifically focusing on SM during the V&V process of LIP's, an evaluation tool has been created based on research into SM within LIP's in general. The four core values underlying the selected CSF's are: *setting goals together, assessing stakeholders, involving stakeholders in the decision-making,* and *continuously interacting with stakeholders*. These values are fundamental to evaluate the SM in relation to the V&V process in practice.

How is SM currently conducted in relation to the V&V process in the design phase?

The role of SM in relation to the V&V process is analysed based on the obtained evaluation tool. Although the basis is similar in every sub-project, it differs how the V&V process and the related SM are implemented during the design phase of LIP's. It appears that there is no standard degree of SM in relation to the V&V process. The case studies have identified an ambiguity in the V&V process, being a more SE-driven or a more SM-driven process. Furthermore, it differs per LIP whether the client or contractor coordinates the design with the stakeholders, and a difference in the degree of collaboration can be recognized.

How does SM affect the V&V process in the design phase?

From the case studies, it can be concluded that *setting goals together*, the first core value of SM, appears to be truly important to the success of the V&V process. Respondents spoke of a major shortcoming in case 2 where no attention was paid to this value, and in the cases where they conducted much attention to this value, this was positively discussed. Respondents believe that by *setting goals together*, parties involved become more aware of the underlying interests and concerns behind the requirements of the project and thus get a better picture of the purpose of the requirements. Consequently, it brings parties closer together from the start. A requirements analysis is seen by every respondent as the right tool to achieve this.

Furthermore, from the case studies it is identified that *continuously interacting with stakeholders* during the process in an open way is important as this creates support from stakeholders and it lowers the chance of unwanted surprises. The frequent design meetings in which the contractor discusses the progress of the design are seen as a meaningful contribution. In these design meetings, it is important not only to focus on the problems that arise but also to take time to reflect on the overall picture and the positive stories of the project.

Both the stakeholders and the client find it very meaningful to be thoroughly informed about the reasoning behind the design choices of the contractor. This applies to *involving stakeholders in the decision-making* as well. The way in which the stakeholders and the client actually participate in making decisions in the studied cases is by means of validation during review moments. The respondents indicated that this is sufficient provided that the stakeholders and client are sufficiently informed about the motives of the contractor. During the design phase, the design meetings are suitable for this and prior to the review moments, the stakeholders and the client would like to receive a presentation about the contractor's design choices with an explanation. This is also in the interest of the contractor as it reduces the chance of an unexpected rejection of the design.

In the cases studied, *assessing stakeholders* did not appear to be important in the V&V process of the design phase. Although little to no attention was paid to this in two of the three cases, two respondents of the stakeholders in those cases had the idea that the client and contractor were aware of them and one indicated that he never saw it as an obstacle that the contractor was not exactly aware of their organization, *"if I can explain it in ten minutes to you, I can do it to them too"*. However, before applying this conclusion in a wider context than these cases, it is meaningful to understand some conditions. The starting point of the V&V process in the design phase seems to be decisive to whether or not *assessing stakeholders* is important. First of all, if people and organizations already know each other from previous phases or projects, *assessing stakeholders* seems less important. Besides, it depends whether or not the requirements are properly representing the interests of the stakeholders and if the value *setting goals together* is conducted well. Some respondents also indicated that the frequency of contact matters, stakeholders refer to the frequent conversations as the reason that the client and contractor are well informed about them.

The comparison between the cases of the Zuidasdok project and the case of the ViA15 project indicates no difference in outcome whether the client or contractor carries out the SM in relation to the V&V process. Much more important seems the degree of collaboration. Both the contractor and the client have the substantial resources that are required to coordinate the design with the stakeholders. The contractor has a better view of the design, whereas the client has already built up a relationship with the stakeholders. Since they have a common interest in monitoring the contract, it is the interest of both of them to enter into good collaboration in managing the stakeholders in relation to the V&V process.

How can stakeholder management help to improve the verification and validation of the stakeholders' requirements during the design phase of large infrastructure projects?

This research shows that good collaboration between the client, contractor, and stakeholders is essential for the performance of the V&V process. It appears that this is not always the case in practice. SM can help by paying accurate attention to *setting goals together* and *continuously interacting with stakeholders* during the design phase in an open way. This will ensure less unwanted surprises for the contractor, client, and stakeholders. Conclusively, this results in quick coordination of the design with the stakeholders in good harmony.

9 Recommendations

9.1 Practical recommendations

This research shows that coordinating the design with the stakeholders does not always run smoothly and can cause both delays for the project, and a bad relationship between the parties involved. Problems seem to arise in the phase in which design requirement are used to make design choices. It is concluded that SM can offer help in improving the V&V process during the design phase. A good relationship between the client and contractor seems to be essential for coordinating the design with the stakeholders and from the case studies it was concluded that a close collaboration between client and contractor is recommended. From this collaboration, the client and contractor can work on a good relationship with the stakeholders. SM can ensure to develop a relationship between the parties involved that suits the interests of the stakeholders, the client and the contractor. This section gives recommendations for putting this SM into practice.

Since it differs between projects whether a client or a contractor is responsible for coordinating the design with the stakeholders and this research has shown that both ways can work, the recommendations stated in this section are made to both client and contractor. The recommendations are based upon the research, and therefore applicable to the design phase of the project.

Core values of stakeholder management

Figure 8 presents the core values of SM and how these can be applied in practice, as learned from the case studies that were considered in this study. The cases reveal that the context can be decisive in determining whether or not the implementation of certain critical success factors is important. This section discusses when and how to address the core values and apply the critical success factors in practice and in various contexts. This can be used to determine an SM strategy in relation to the V&V process.

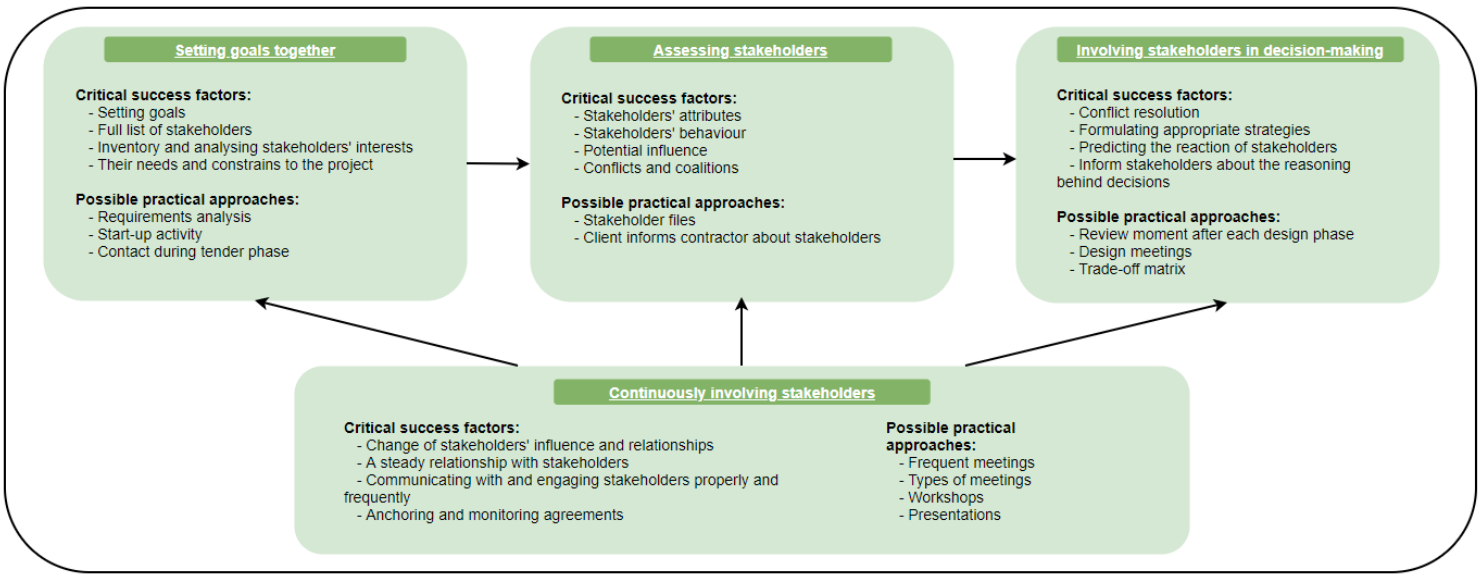


Figure 8: Guidelines for determining SM strategy in relation to the V&V process

Setting goals together

Under the different conditions of the studied cases, *setting goals together* was always considered important by the respondents. It is therefore advised to pay close attention to this core value of SM at the beginning of the design phase in any case. Although the factor ‘full list of stakeholders’ was not mentioned by the respondents, it can be expected that in some cases this can be helpful for the V&V process. The starting point is decisive in this. This research is focused on the design phase, so it

depends on what is already known from the preliminary phase of the project. Even in the second case of this project, where little attention was paid to this core value, the respondents indicated that it was clear who all stakeholders were. Although the stakeholders in relation to the V&V process are usually known through their contractual relationship, it is recommended to check this at the beginning of the design phase. This can be done by examining the requirements and checking whether it is known which requirement originates, or which is affected by which stakeholder.

The other critical success factors of this core value are all indicated to be very important to the V&V process. In the cases studied, the contractor was a party that was just on board and it is therefore important to set goals together, taking into account each other's interests, needs and constrains. All respondents highly recommended a careful requirements analysis and it is therefore recommended to conduct this practical approach at the beginning of the design phase. Furthermore, it is always recommended to carry out a start-up activity at the beginning of the design phase for team building with between the client, contractor and stakeholders.

Assessing stakeholders

The starting point of the V&V process in the design phase seems to be decisive to whether or not *assessing stakeholders* is important and how it should be implemented. Often, the client has already carried out an analysis to assess the stakeholders resulting in stakeholder files. In addition, the stakeholders related to the V&V process have a contractual connection with the project. This means two things, firstly, a relationship has already been built up between the stakeholders and the client and secondly, it implies that the stakeholders are in any case connected to the process.

It is advised to assess the available information on the stakeholders at the beginning of the design phase: what is already known about the stakeholders and has this already been documented? If little is known about the stakeholders, it is recommended to request information from the client. The client can probably hand over stakeholder files, otherwise the contractor is advised to write these themselves, preferably together with the client. However, it can be concluded from the cases considered that it is not very important to invest a lot of time in this core value of SM.

Involving stakeholders in decision-making

Stakeholders related to the V&V process are asked for their approval of the design after every design phase in every LIP. That degree of involvement in the decision-making seems to be sufficient provided that stakeholders are properly informed of the motives of the contractor in making certain design choices during the process. Therefore, the involvement of stakeholders in decision-making is very much related to the fourth core value of SM (*Continuously involving stakeholders).* It is particularly advised that the contractor gives a presentation prior to the review moments to explain their motives in the design choices made, as this ensures a better understanding from the stakeholders and it lowers the chance on unwanted surprises.

The starting point (i.e. beginning of the design phase) is also important for this core value. Properly set goals in consultation with client, contractor, and stakeholders (first core value) at the beginning of the design phase generate more confidence among the stakeholders about design choices to be made by the contractor. Under these conditions, the involvement of stakeholders in decision-making is less needed.

This research has shown that it can be very difficult to reach a joint decision when an issue affects several stakeholders. There is a tendency to approach stakeholders individually, while the respondents agree that it is better to bring them together and openly discuss the issue with each other. It is therefore recommended to bring all parties that are affected by a particular issue together as soon as possible, and ensure an atmosphere in which parties are open and transparent about their interests and concerns. In addition, this research has shown that the client sometimes decides to make decisions together with

the stakeholders and to leave the contractor out of this. This is strongly discouraged, as the contractor is closest to the design process and can therefore make a major contribution to making decisions.

Continuously involving stakeholders
In the different contexts of the studied cases, *continuously involving stakeholders* was always considered important by the respondents. As a basis, the frequent design meetings are suitable for involving stakeholders. In these design meetings it is important not only to focus on the issues that arise, but also to take time to reflect on the positive stories. In the same line of thought, it is recommended not only to maintain contact with the stakeholders affected by an issue during the process, but also to maintain contact with stakeholders who are not involved in an issue. In this way, one stays informed of the stakeholders.

Frequent contact with the stakeholders through the design meetings keeps the client and contractor informed of the changes in stakeholders' interests, needs, concerns, influence and relationships. In a LIP with a long-term and dynamic character it is very important to be sharp on potential changes. In addition to the design meetings, different situations will require their own approach. For example, if a stakeholder has little experience with a LIP, the client and contractor will have to maintain a more guiding role and often a higher frequency of contact is required, whereby attention must be paid not only to content but also to the process. When there is a fragile relationship with one of the parties involved, it is recommended to have more meetings as well, again focussing on the process.

During the contact moments ,it is very important to record what has been agreed, such that it can be monitored whether the right design has been made, and in the right way. Especially in dynamic contexts, this helps to avoid endless discussions. When the wishes of the stakeholders are properly recorded, the project team can look at what can be done with it and whether it falls within the contract and then come back to the relevant stakeholder.

Formal or informal approach
As presented in Chapter 1, the V&V process consists of a few formal moments to verify whether the requirements are met and validate whether the design is in line with the intended use of the stakeholders and client. It depends on the stakeholder and the relationship with the stakeholder whether a more formal or a more informal approach is appropriate. In one of the studied cases, the stakeholder, client and contractor had a common understanding of what the V&V process entails and were all very experienced with SE. In that context, a formal approach is advised as this seems to be the effective way to go through the V&V process. However, if a stakeholder has little experience with a LIP, it is recommended to take a more informal approach. Besides, if there is a fragile relationship with a stakeholder, it is also advised to have a more informal approach.

Interrelated or separated processes
Based on this research, it is recommended to perform interrelated processes in relation to the V&V of stakeholders' requirements. By working in an integrated manner, people stay informed about each other and they can react faster and more flexible to changes during the process. Besides, stakeholders are closer to the design process.

Context of this research
When determining an SM approach in relation to the V&V process based on the aforementioned recommendations, it is important to realise the context of this research. The entire V&V process of a LIP comprises the process from the preliminary phase to the maintenance phase, this research has focused on the design phase solely, and therefore only has recommendations for this part of the V&V process. The client and contractor must therefore be aware of their starting point when determining an SM strategy in relation to the V&V process and take into account the phases ahead.

9.2 Scientific recommendations

In addition to the new insights to which this research has led, it has also thrown up a number of interesting questions for further investigation. These questions have already been introduced in Chapter 7, this section presents the most decisive ones and recommends how to follow up on them.

First of all, it is recommended to further test and specify the theoretical framework by using the findings from this research. As explained, literature has been used on SM focusing on LIP's in general, so this research can be seen as an exploratory study into the role of SM in relation to the V&V process. To investigate how SM is currently conducted in relation to the V&V process, a select number of cases were thoroughly investigated. To increase the accuracy and reliability of this study, it is recommended to test the results of this study on a larger scale.

A noteworthy question that still remains is: what is the correlation between the relationship between the client and the stakeholders during the preliminary phase with the performance of the V&V process during the design phase. Relationships built up in the preliminary phase were outside the scope of this research, but it is expected that these relationships have influence on the optimal SM strategy. For this reason, it is recommended to conduct follow up research into this correlation and find ways to deal with it.

From the case studies, it is concluded that *continuously interacting with stakeholders* in an open way is important. However, open communication with the stakeholders entails the risk of an intentional or unintended deviation from the contract without proper agreements about the possible consequences. Several respondents advise to involve contract managers closely in this process, to ensure compliance with the contract. However, the close involvement of contract managers can also radiate lack of confidence. The role that contract management can have in relation to the V&V process falls outside the scope of this study, nonetheless this is a very interesting question. A further study with more focus on contract management is therefore suggested.

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Appendix A – Systems engineering in Dutch LIP's

As mentioned in Chapter 1, the V&V process is carried out according to the SE Guideline. This appendix therefore provides insight into what the V&V process should look like according to the SE Guideline. The first section of this appendix provides the SE principles on which the SE Guideline is based. Section A.2 then describes how the V&V process should be set up according to the SE Guideline. Section A.3 describes how the SE Guideline advises to involve stakeholders.

A.1 Origin of the SE Guideline

The SE Guideline has been drawn up for the Dutch civil engineering sector by a collaboration between clients and contractors (Rijkswaterstaat, ProRail and various branch organizations). SE is used at complex systems, where the system is divided (decomposed) into smaller, easier to handle pieces. The SE Guideline uses the definition for SE from the International Council on Systems Engineering (INCOSE) which reads: "An interdisciplinary approach and means to enable the realization of successful systems. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs." (INCOSE, sd). In the SE Guideline five important principles of the SE philosophy are described (ProRail, Rijkswaterstaat, Bouwend Nederland, NL ingenieurs, de Vereniging van Waterbouwers, Uneto-VNI, 2013), which are:

1. *Systems thinking:* SE is based on systems thinking. Within the total reality, a system is a collection of elements that have mutual relationships. Every system takes part in a bigger picture. With systems thinking, organizations take into account the complete system, the life cycle and all the parties involved.
2. *Customers demand is central:* With the use of SE in projects, problems and chances are analysed related to the customers' demand. Within SE, customers' needs are translated into customers' requirements which are recorded in the CRS (see Appendix B). During the development of the system, SE focuses on continuous coordination with the current customers' demand.
3. *Life cycle optimization:* SE focuses on optimizing the system in all its phases and in mutual cohesion over the entire life cycle.
4. *From abstract to concrete:* During the development of the system, SE works from abstract to concrete. The process starts with abstract customers' questions, which through iterative specification and decomposition ultimately results in a concrete solution.
5. *Work explicitly:* During the life cycle of systems, there is a regular transfer between different teams working on the same system. Different teams, sometimes at different locations, also work on the same system at the same time. According to the SE philosophy, this asks for a clear and unambiguous recording of information so that choices and information are transferable. The V&V process is seen as important support.

A.2 V&V according to the SE Guideline

Decomposing the system into smaller, easier to handle pieces is also referred to as iterative specifying. To meet the customers' needs, a system must fulfil a number of functions. The system requirements follow from these functions. Several design choices are possible within the given solution space to meet these requirements. The process within SE is based on an iteration between functions, requirements and solutions. By recording requirements, it is determined within which solution space the system must function. Design choices determine how the system fulfils those functions and which solution space is used. This in turn leads to derived functions and further requirements for the further development of the system. In complex systems, the iterative process of specification repeats itself at multiple levels of detail. Figure 10 shows the iterative process of specifying. At every level of detail, it is important to verify the designs against the requirements at the relevant level. In addition, the choices made must be validated against the intended use (ProRail, Rijkswaterstaat, Bouwend Nederland, NL ingenieurs, de Vereniging van Waterbouwers, Uneto-VNI, 2013). In LIP's part of this development is done by the client

and part by the contractor, so a transition takes place during the process. In this transition, it is essential that attention is paid to the responsibilities in the field of V&V activities and that agreements are clear. In general terms, the client is responsible before the transition and the contractor after the transition. However, the development of the system is separate from the transition, activities continue but are then performed by another team. This is shown in Figure 9.

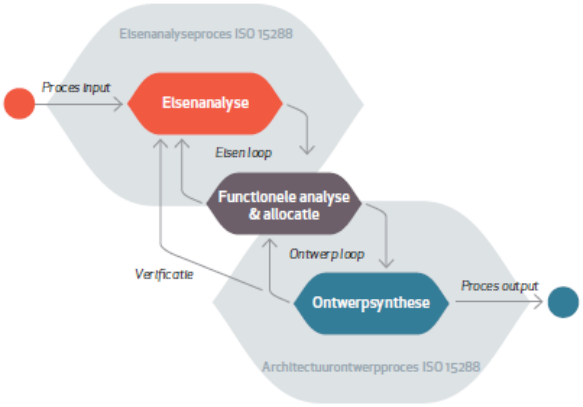

Figure 10: Iterative process of specifying

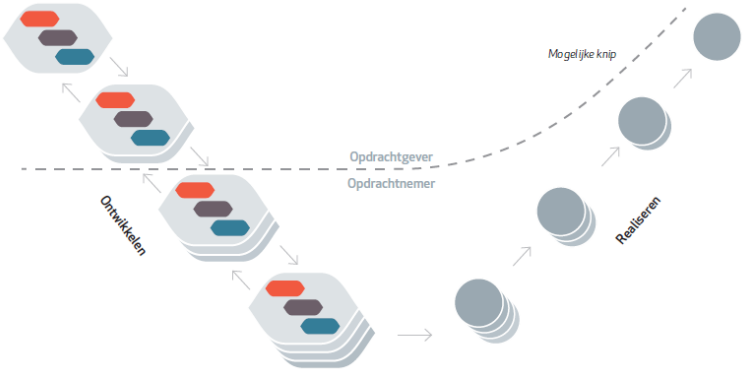

Figure 9: The transition between the client and contractor

So, during this iterative specification process, verifying and validating is carried out at every level of detail and at all stages of the life cycle. Within the SE Guideline, the V&V process is defined as follows (ProRail, Rijkswaterstaat, Bouwend Nederland, NL ingenieurs, de Vereniging van Waterbouwers, Uneto-VNI, 2013):

> *Verification process*: The purpose of this process is to determine that the system meets the specified system requirements.
>
> *Validation process*: Here it is assessed whether the requirements of the stakeholders have been worked out correctly within the system.

The needs and wishes of the stakeholders are identified by the client in the preliminary phase and are recorded in customers' requirements and wishes. During a requirements analysis, see Figure 10, these wishes and needs are analysed and translated into a set of system requirements. To ensure that the translation takes place correctly, it is presented to the stakeholders (validation). Rijkswaterstaat is using the CRS for this process (see Figure 11). The systems requirements are then input for the designs that are being developed and can also be tested against these requirements (verification). Subsequently, the designs can also be presented to the stakeholders (validation) (ProRail, Rijkswaterstaat, Bouwend Nederland, NL ingenieurs, de Vereniging van Waterbouwers, Uneto-VNI, 2013).

Both the client and the contractor write their strategy for the V&V process in their own V&V management plan. The client starts with its V&V process in the preliminary phase and the contractor continues with this in the tender phase. The V&V management plan establishes, among other things, which phases and methods are used, which formats are used and which organization and resources are available for this. Depending on the size and complexity of the project, a list of V&V methods, criteria and phases of demonstration per requirements can also be added in the V&V plan. For the contractor, it is important here to take into account the V&V methods and criteria already prescribed by the client. The V&V management plan of the contractor must be coordinated with the client so that there is prior agreement on how V&V takes place in the project. Furthermore, it is important to make agreements with stakeholders about the methods and criteria that are used to V&V the requirements. The results of the V&V activities are recorded in V&V reports. These are eventually included in the V&V register (ProRail, Rijkswaterstaat, Bouwend Nederland, NL ingenieurs, de Vereniging van Waterbouwers, Uneto-VNI, 2013).

It is emphasized that SE must be tackled integrally, with attention paid to processes, procedures, tools, knowledge and culture. It is seen as a pitfall to see SE as a specialism and to make it a separate sub-project. For a successful implementation of SE, every organization must translate the method into a concrete application. How this is implemented depends on the company and the business processes.

A.3 Advice on involving stakeholders according to the SE Guideline

The SE Guideline provides some advice on involving stakeholders during the process. As the client identifies the stakeholders in the preliminary phase, it is stated that it is also advisable for a contractor to map out the stakeholders and determine the influence of these stakeholders. The analysis provided by the client can serve as a basis for this. The stakeholders can be different per phase and their interests can also change, it is therefore important to keep this analysis up to date. The SE Guideline advises that all relevant stakeholders must be involved in the design choices from the start of the design, including internal stakeholders such as the operator and maintenance organization. These organizations must also adopt a proactive attitude themselves. After the realization of (part of) the system, the system is transferred to the operator. An operator must therefore be involved in time to determine which data is required to transfer the (sub) system, but also to determine procedures, working methods and, for example, train operators.

Many agreements were made with stakeholders in the phases prior to the tender. These are not always included in the contract. Sometimes, however, stakeholders want to revise previously made agreements or come up with new requirements. The SE Guideline therefore state that it is important that agreements made are properly recorded. This prevents discussion afterwards.

In order to be able to collaborate with more design freedom, the client and contractor can work together to give substance to the solution space. The SE Guideline does not mention the stakeholders to be involved in this discussion.

Appendix B - V&V process during the preliminary phase

A Dutch LIP starts with the initiation of the central government where Rijkswaterstaat (or another government body) identifies a bottleneck or problem, for which a solution is necessary. The central government decides if an infrastructural project needs to be executed. Thereafter, Rijkswaterstaat acts as the public client towards the private market (Rijkswaterstaat, 2014). In collaboration with stakeholders in the area, the central government and region have the aim to clarify the joint ambitions and to identify challenges. Thereafter, a wide range of possible actions and measures is sought based on thorough problem analysis. Rijkswaterstaat goes through a funnelling process: from broad analysis and inventory of possible solutions, funnelling towards one administrative preference decision ('Voorkeursbeslissing' in Dutch). As part of this process, Rijkswaterstaat investigates the wishes of the stakeholders. Furthermore, it is examined whether early involvement of the market has added value in this phase and, if so, how the market can be involved. The essence of the preference decision is that there is (financial) central government involvement and there is an agreement between the parties involved about the preferred solution to be implemented or the related program of measures (including the availability of sufficient financial resources). The parties involved will make agreements about the follow-up phase and preferably record these in a management agreement ('Bestuursovereenkomst' in Dutch). The preference decision discusses whether and how the project will be carried out, which is then submitted to the House of Representatives ('de Tweede Kamer' in Dutch) (Ministerie van Infrastructuur en Milieu, 2016).

After the preference decision is made and submitted to the House of Representatives (see Appendix A), RWS is starting with their V&V of stakeholders' requirements. Thereby, RWS is using the Customer Requirements Specification (CRS) as a tool in every LIP[25]. The CRS process is carried out according to the SE Guideline ('Leidraad Systems Engineering' in Dutch) (Rijkswaterstaat, 2019). SE is aimed at optimizing the system to stakeholders' requirements over the entire life cycle. Choices are made and recorded during the life cycle. Transfer moments also take place between the different project phases. RWS sees it as essential to explicitly identify, record and manage stakeholders' requirements (Rijkswaterstaat, 2019). In this way, RWS tries to keep a documented record of what has been agreed with the parties involved so that it can be reverted to later. The CRS process has the project documents from the preference decision as input and a contract specification for outsourcing work to the contractor as output.

Figure 11 shows the CRS process used by RWS to manage the stakeholders' requirements. In Figure 11, the input for the process is shown in yellow and the output of the process in green. The steps of the CRS process are numbered in the figure and are explained below (Rijkswaterstaat, 2019).

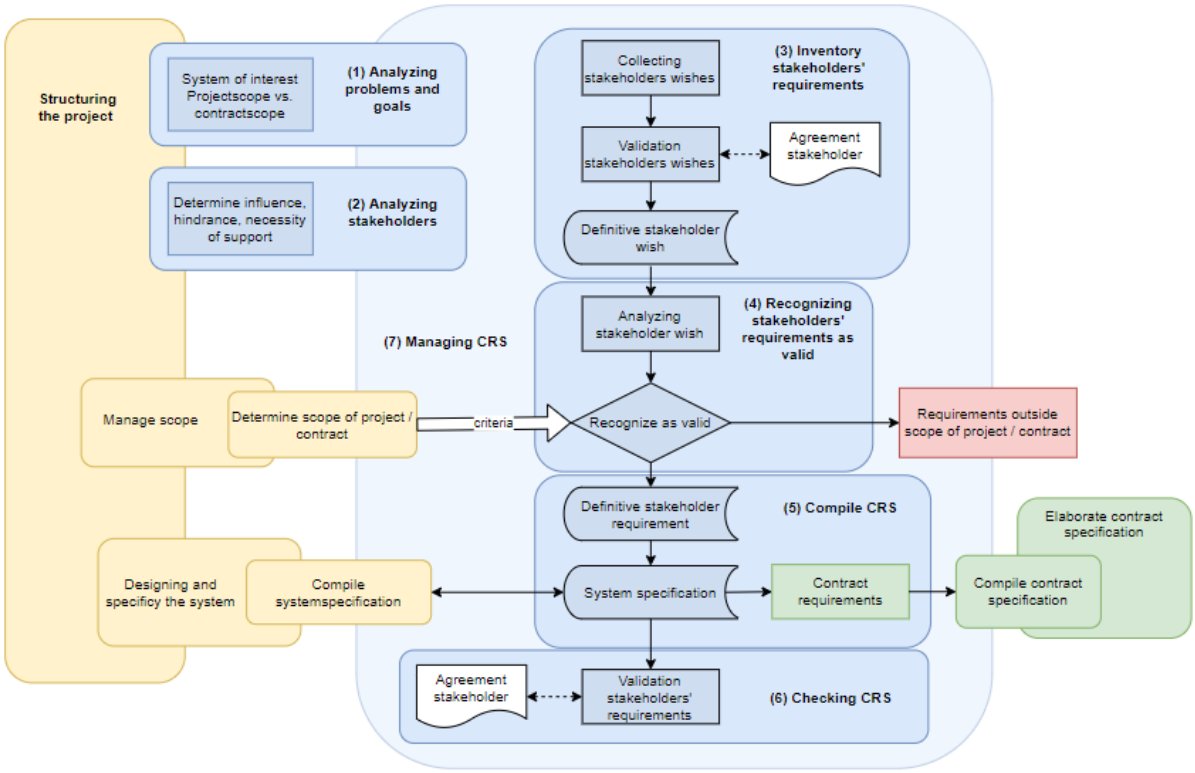

Figure 11: The procedure of CRS used by RWS.

(1) Analysing problems and goals*:* Analysing stakeholders' wishes starts with a problem analysis and definition of the project objectives. The goal of this first step is to gain insight into the problem to be solved and the associated project objectives.

(2) Analysing stakeholders: This step builds on the previously conducted stakeholder analysis from the initiation phase. More extensive research is being conducted into the stakeholders, their interests and influence using an environmental analysis.

(3) Inventory stakeholders' requirements: The wishes of the stakeholders are collected based on the environmental analysis. After collecting the stakeholders' wishes, there is a moment where the wishes of the stakeholders are validated. In this way, RWS tries to prevent wishes from being misinterpreted.

(4) Recognizing stakeholders' requirements as valid: RWS will analyse the definitive stakeholders' wishes from the third step by using the (then applicable) project scope. It is important that the project organization remain aware of the wishes that fall outside the project scope in case scope changes occur. Also for validation in the future, it is important to record both original stakeholders' wishes (obtained from stakeholders) and derived formulations for each iteration in the process[5].

(5) Compile CRS: In this step, the output of all previous steps is structured and documented. In addition, the wishes of the stakeholders have been transformed by RWS into functional requirements for the contract. RWS has the underlying wishes of the stakeholders in his archive but does not always share this with the contractor[5].

(6) Checking CRS: The quality of the CRS is being checked in this step. RWS checks whether the customer requirements are suitable as a basis for validation to be carried out later, the following questions need to be answered:

- Have all relevant stakeholders been approached?
- Are all issues relevant to this phase been identified and sufficiently elaborated?
- Is the translation of stakeholders' wishes to stakeholders' requirements coordinated with the stakeholders?

- Does the CRS make clear when the stakeholders are satisfied with the result?
- Has an appropriate evidence method been agreed with the stakeholders?
- Has it been agreed with the stakeholders in which phase they will get and confirm the result? Furthermore, it is being checked whether all the steps have been carried out carefully. Again, there is a validation moment with the stakeholders to get an agreement about the stakeholders' requirements.

(7) Managing CRS: This is an ongoing process throughout the project. RWS must monitor the CRS and manage changing stakeholders' requirements. The CRS process is iterative, new stakeholders' requirements (and sometimes new stakeholders) are identified when developing the design.

In the fifth step of the CRS, RWS is translating the stakeholders' requirements into requirements for the contract. These contract requirements are then input for the tender phase in which RWS searches for a contractor. After the tender phase, the project is awarded to a contractor.

Appendix C – Interview protocol

During the case studies, the most important way to gather information is through in-depth interviews with experts in the field. In this appendix, the interview protocol is written which is used for the case studies. The type, goal, strategy and structure of the interviews are elaborated and the choice of the particular respondents will be explained. Moreover, this appendix describes the way of processing the interviews.

C.1 Type of interview

There are various approaches to perform an interview, from a perfectly structured way in which the respondents respond to a limited number of predefined questions to a totally unstructured way in which the respondents are given the freedom to speak about whatever they wish. Within this spectrum, three main types can be described: structured, semi-structured and unstructured (Fox, 2009).

In a structured interview, the interviewer draws up all the questions in advance and during the interview, the interviewer stick exactly to these questions and the specific order and repeat this process in each interview. Often there is even an indication of the possible answers (Baarda & van der Hulst, 2017). The interviews are relatively short and this way of interviewing is easy to process, but the disadvantage is that interviews may lack in depth because it does not provide the option for follow up questions.

A little bit less structured way of interviewing is interviewing according to a semi-structured form. These are similar to structured interviews in the sense that the topics are predefined, but open questions are used and there is room for follow up questions. This provides the freedom to discuss certain topics in more detail, although it is more difficult to process results than structured interviews (Fox, 2009).

Unstructured interviews can be compared to normal conversations with someone. The interview contains little or no structure at all, making it possible for the interviewer to respond flexibly during the interview. Instead of defining questions in advance, the interviewer frames the questions in response to the respondent's previous answer (Fox, 2009). The advantage of unstructured interviews is that the interviewer can conduct more in-depth interviews, but the disadvantage is a really time-consuming process with little consistency in the collected data.

As this research contains qualitative case studies with predefined topics to investigate, the data is collected using semi-structured interviews. The evaluation tool, Figure 4 of section 3.4, is used to structure the interviews and to determine the topics to address.

C.2 Goal of interviews

The goal of the interviews is to investigate the different perspectives on the application of SM in relation to the V&V process of the design phase, so that afterwards a link can be made between the quality of the V&V process and executed SM.

C.3 Strategy of interviews

First, the different perspectives on the V&V process of stakeholders' requirements is investigated. In this way, it becomes known what the respondents consider important for the process, without already asking specific questions about SM. Then, the performance of SM will be evaluated by using the evaluation tool (Figure 4) as a starting point.

This research tries to gain insight into the different perspectives of the parties involved in the V&V processes of the cases, this is done by interviewing experts of the client, contractor, and stakeholders. In order to select the right respondents and to make sure that every respondent debates the same process, several subjects are selected which will be discussed during the interviews. The subjects are parts of the design where there has been much discussion about the requirements and/or amendments

that went with them. The subjects are chosen in consultation with the stakeholder relationship manager of each case.

C.3.1 Preparation

The key to a successful interview is good preparation. Through the empirical study into the V&V process (Chapter 1) and the literature study into SM in LIP's (Chapter 3), substantive knowledge is gained as a preparation on the background of the subjects from the interview. The interviews are part of the case studies, therefore information about the cases is gathered prior to the interviews.

The network of HOCHTIEF is used to find the right respondents who have been involved in verifying and validating the design of the cases. The desired respondents will be contacted by email to ask whether they want to participate in the interview. In this email, a short introduction to the research will be given, they will be informed about the expected duration of the interview (one and a half hour) and, due to COVID-19, the respondents will be asked whether they want to meet in real life or via an online platform.

When an appointment is made with the respondents, the following information will be given through email:

- The selected case.
- The type of interview: semi-structured with fixed topics.
- The main topics of the interview
- It will be asked if they agree to a recording device, with the note that only the researcher will be able to listen to it.
- It will be proposed to send the report of the interview afterwards so that the respondent can check on validity. The interview reports will only be used for this research, conducted on behalf of HOCHTIEF and the TU Delft.

C.3.2 Points of attention during interviews

Various literature elaborates techniques and strategies to conduct a professional interview (Rijksuniversiteit Groningen, 2019; Gils, 2013; Swaen, 2019). Some points of attention are elaborated upon:

- The introduction is the foundation for the conversation, therefore:
    - A clear and complete picture must be given to the interviewee and the purpose of the interview.
    - A pleasant atmosphere must be created.
- During the interview, the aim is to get the most complete answer to the questions. Some tips are:
    - Focus on listening instead of talking.
    - Do not try to fill the silences in a conversation.
    - Use clear questions and be kind in the formulations.
    - Avoid loaded terms.
    - Keep in mind who the respondent is.
    - Do not assume too much as known.
    - Repeat the question.

C.4 Structure of interviews – For client and contractor

(Because the interview is conducted with Dutch respondents, the interview questions are drawn up in Dutch)

Mijn achtergrond / onderzoek (5 min)

- Civiele Techniek - Construction Management and Engineering - TU Delft

- Afstudeeronderzoek naar de verificatie en validatie van eisen van stakeholders

0. Achtergrond respondent (10 min)

- Kunt u uw functie met de bijbehorende werkzaamheden beschrijven binnen het project?
  - Betrokkenheid in project? Vanaf – tot ?
  - In welke rol of rollen was u betrokken?
  - Heeft u eerder aan grote infrastructuur projecten gewerkt?
  - Zo ja, welke?

1. Perspectief op uitgevoerde V&V proces (30 min)

- Zou u het algemene V&V proces van het project kunnen beschrijven tijdens de ontwerpfase?
  - Wat vond u van de kwaliteit van het V&V proces?
  - Had u het idee dat er volgens een duidelijk stappenplan werd gewerkt?
  - Wat ging er goed? Wat ging er minder goed?

- Hoe is er binnen casus XXX omgegaan met het V&V proces tijdens de ontwerpfase?
  - Zijn er specifieke plannen voor het deelproject geschreven?
  - Wat ging er goed? Wat ging er minder goed?
  - Hoe verliep de V&V bij de genoemde voorbeelden?
  - Hoe kwam dit volgens u?

- Wanneer ziet u de V&V van een eis tijdens de ontwerpfase als succesvol?

- Wat denkt u dat belangrijk is voor het soepel laten verlopen van de V&V van stakeholder eisen?
  - Wat voor activiteiten zijn daarvoor georganiseerd?
  - Wat vond u daarvan?

- Hoe werd de afstemming van het ontwerp met de stakeholders gedaan?
  - Hoe werden stakeholders betrokken in het V&V proces?
  - Wat voor activiteiten zijn daarvoor georganiseerd?
  - Iemand van afdeling omgevingsmanagement betrokken?

2. Perspectief op belangen (15 min)

- Kunt u vertellen wat het belang van uw organisatie was bij het V&V proces?
  - Was dat belang ook bij de andere partijen bekend?
  - Is dat belang ook behartigd door de invulling van de eisen?

- Kunt u wat vertellen over de belangen van de andere partijen?
  - Belang van de OG/ON?
  - Belang van de stakeholders?
  - Heeft u het idee dat die belangen zijn behartigd?

3. Perspectief op invulling SM (30 min)

- Hoe is ervoor gezorgd dat vanaf de start van de ontwerpfase met alle betrokken partijen aan een gezamenlijk doel werd gewerkt?
  - Wat voor activiteiten zijn daarvoor georganiseerd?
  - Het belang van de stakeholder en OG bekend?
  - Zijn de behoeften, beperkingen en problemen bij elkaar bekend?
  - Bijvoorbeeld de issues uit eerdere fases?
  - Is er een gezamenlijk doel opgesteld met alle betrokken partijen?
  - Heeft u het idee dat de OG en stakeholder voldoende informatie hadden over uw organisatie?

- Aan ON: Hoe is er intern bij de ON voor gezorgd dat een juiste inschatting is gemaakt van de verschillende partijen?
    - Wat voor activiteiten zijn daarvoor georganiseerd?
    - Zijn er analyses gemaakt van de diverse stakeholders?
    - Heeft u deze analyses ingezien?
    - Was er iemand van de afdeling omgeving betrokken bij het V&V proces?
    - Heeft u het idee dat er een juiste inschatting was gemaakt van de stakeholders?
    - Was u op de hoogte van de mogelijke coalities en conflicten tussen de stakeholders?

- Aan OG: Hoe is er intern bij de OG voor gezorgd dat een juiste inschatting is gemaakt van de verschillende partijen?
    - Wat voor activiteiten zijn daarvoor georganiseerd?
    - Zijn er analyses gemaakt van de diverse stakeholders?
    - Heeft u deze analyses ingezien?
    - Heeft u het idee dat er een juiste inschatting was gemaakt van de stakeholders?
    - Was u op de hoogte van de mogelijke coalities en conflicten tussen de stakeholders?
    - Heeft u het idee dat de ON een juiste inschatting heeft gemaakt?

- Hoe werd invulling gegeven aan de besluitvorming van de eisen in de ontwerpfase?
    - Wat voor activiteiten zijn daarvoor georganiseerd?
    - Betrokkenheid stakeholders? Hoe bepaald?
    - Is er een strategie per stakeholder bepaald?
    - Is er getracht conflicten op te lossen tussen de partijen en hoe is dit gedaan?
    - Is er gezocht naar een win-win situatie?

- Hoe werd er gezorgd voor draagvlak van de stakeholders gedurende het project?
    - Wat voor activiteiten zijn daarvoor georganiseerd?
    - Communicatie: frequentie en uitvoerigheid. Hoe bepaald?
    - Openheid van communicatie? Bewust van verschil in perspectief?
    - Afspraken vastgelegd en gemonitord?
    - Werd eigen werkwijze m.b.t. SM tussentijds geëvalueerd?
    - Werd vaak gesproken over het gezamenlijke doel?
    - Werden er wel eens intern sessies gehouden om over de belangen, invloed/macht en issues met stakeholders te praten?

4. Afronding (5 min)

- Heeft u nog inhoudelijke toevoegingen aan het interview?
    - Niet gestelde vragen

C.5 Structure of interviews – Stakeholders

Mijn achtergrond / onderzoek

- Civiele Techniek - Construction Management and Engineering - TU Delft
- Afstudeeronderzoek naar de verificatie en validatie van eisen van stakeholders

0. Achtergrond respondent

- Kunt u uw functie met de bijbehorende werkzaamheden beschrijven met betrekking tot het project?
    - Betrokkenheid in project? Vanaf – tot ?
    - In welke rol/rollen was u betrokken?
    - Bent u eerder betrokken geweest bij een groot infrastructuur project?

- Zo ja, welke?
- Bent u betrokken geweest bij het opstellen van de eisen voor het project?

1. Perspectief op kwaliteit uitgevoerde V&V proces

- Hoe is uw organisatie betrokken bij het opstellen van de eisen in de voorfase van het project?
  - Wat voor activiteiten werden daarvoor georganiseerd?
  - Bent u daar tevreden mee?
  - Wat had u graag anders gezien?
  - Vond u dat u op een duidelijke, gestructureerde manier werd betrokken en wat vond u daarvan?

- Hoe is uw organisatie betrokken bij het ontwerpproces tot nu toe?
  - Wat voor activiteiten zijn daarvoor georganiseerd? Door de OG of ON?
  - Bent u daar tevreden mee?
  - Wat had u graag anders gezien?
  - Vond u dat u op een duidelijke, gestructureerde manier werd betrokken en wat vond u daarvan?
  - Heeft u voornamelijk contact met de OG of de ON? Wat vindt u daarvan?

- Hoe is uw organisatie betrokken in de ontwerpfase m.b.t. casus XXX en de genoemde onderwerpen?
  - Wat voor activiteiten werden daarvoor georganiseerd? Door de OG of ON?
  - Bent u daar tevreden mee?
  - Wat had u graag anders gezien?

- Bent u tevreden met de ontwerpkeuzes die uiteindelijk zijn gemaakt?

2. Perspectief op belangen

- Kunt u vertellen wat het belang van uw organisatie was?
  - Was uw belang ook bij de andere partijen bekend?
  - Is dat belang ook behartigd door de invulling van de eis?

- Kunt u wat vertellen over de belangen van de andere partijen?
  - Belang van de OG
  - Belang van de ON
  - Heeft u het idee dat die belangen zijn behartigd?

3. Perspectief op invulling SM

- Hoe werd er aan het begin van de ontwerpfase voor gezorgd dat er naar een gezamenlijk doel zou worden gewerkt met de verschillende belangen in het achterhoofd?
  - Heeft u het idee dat daarvoor is gezorgd?
  - Welke activiteiten werden hiervoor georganiseerd?
  - Door de OG of de ON?
  - Gezamenlijke doelen
  - Op de hoogte van elkaars belang?
  - Op de hoogte van de heersende issues?

- Had u het idee dat de ON en OG goed op de hoogte waren van uw organisatie en relatie ten opzichte van het project?
  - Invloed / macht
  - Capaciteit en bereidheid om mee of tegen te werken
  - Heersende conflicten / coalities

    - Heeft u enig idee hoe zij geprobeerd hebben om goed op de hoogte te zijn van uw organisatie en uw standpunten en invloed?

- Hoe werd u betrokken bij de besluitvorming van de ontwerpkeuzes in de ontwerpfase?
    - Welke activiteiten werden hiervoor georganiseerd?
    - Door de OG of de ON?
    - Gestreefd naar een win-win situatie?
    - Conflict oplossend onderhandelen?
    - Bent u daar tevreden mee?
    - Hoe had dit beter gekund?

- Heeft u het gevoel dat er binnen uw organisatie draagvlak was voor het project tijdens de ontwerpfase? Hoe werd daarvoor gezorgd?
    - Welke activiteiten werden hiervoor georganiseerd?
    - Door de OG of de ON?
    - Communicatie: frequentie en uitvoerigheid?
    - Afspraken vastgelegd en gemonitord?

4. Afronding

- Heeft u nog inhoudelijke toevoegingen aan het interview?
    - Niet gestelde vragen

Mijn voorstel zou zijn dat ik u de notulen van het interview toestuur, zodat u nog even kunt kijken of ik alles goed heb genoteerd. Bent u het daarmee eens?

C.6 Processing interviews

Once the interviews have been conducted, it is important to present them in a clear and orderly manner. The data from the recording device will be transcribed, which means that the interviews are written down word by word. By recording interviews and making a transcript, the results stay close to reality, making it more reliable (Tubbing, 2019). This generates a lot of data where coding can provide structure. The predefined topics of the semi-structured interviews can be used as a starting point for the coding process. To encode a qualitative interview, it is useful to go through three different phases: open, axial and selective coding. Keywords are connected to the answers of the respondents. Based on this, connections can be made between the various answers from which conclusions can be drawn.

However, most respondents only approved a summary of the interview as an appendix to this report. Therefore, after coding the interviews, a summary of each interview was written and the respondents' approval was requested. These reports summaries are found in Appendix D – Interview reports.

Appendix D – Interview reports

The interview reports can be requested from the author G. Ridderinkhof