TOWARDS PERCEPTION-BASED MANAGEMENT OF COMPLEXITY IN CONSTRUCTION PROJECTS

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Kennis in het groot.





Towards perception-based management of complexity in construction projects

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“The only place success comes before work is in the dictionary„

- Vince Lombardi

Preface

My master programme *Construction Management and Engineering* had a strong focus on the management of *complex* projects. But I always wondered: what are complex projects? The term was often used, both in education and in practice, to classify projects and processes but it never became clear to me what made these projects 'complex'. When I saw the application for a graduate research on this topic I immediately knew that this research could fill this knowledge gap; and it did.
Another side of the research that I found very attractive was the overlap with other knowledge areas outside the technical spectrum. If there is one thing that I have learned from my Masters it is the strength of multidisciplinary knowledge and teams.
This research therefore borrowed some ideas of other knowledge fields and was conducted at the edge of what can be considered as a topic for a thesis from a technical university: it was and still is my opinion that the road towards well performing projects can only be paved by combining multiple knowledge areas (especially alpha- and beta-disciplines) and thereby creating multidisciplinary knowledge.

This research would not have been possible without the excellent supervision of my graduation committee and I would like to thank them for their contribution to this thesis. Marian, not only were you able to make lots of time available but you were also able to provide excellent feedback and you were an exceptionally good sounding board for my ideas and questions. Maarten, your enthusiastic feedback motivated me to deliver the best results possible and your practical insights guided me through some very difficult topics. Wijnand, your contributions during committee meetings were critical and therefore helpful and Marcel, thank you for the feedback that you delivered during the research.

A special thanks goes to all the 30 interviewees; I must admit that it was a tough job to travel thousands of kilometres around the country during an excellent and very hot summer but it turned out to be worth it: not only did I receive enough data to perform my research, I also gained insights into the miraculous world of construction projects from all different kind of angles. This made the research both interesting and fun at the same time!

I also would like to thank all people working at KING/RPA that helped me with the research, especially with the practical organisation: I could not have pulled of 30 interviews without your help and it was a unique experience to be able to present my findings during the *café college*, thank you for that opportunity!

And last but not least I would like to thank Jeroen, Nicole, Karen and Carla for taking the time to review this thesis: it is nice to know that at least four people besides the graduation committee read this thesis.

Bram Kool
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Summary

Introduction

Project complexity is a phenomenon which is often accused of being the cause for project failure in large construction projects. It is also believed that complexity within these projects is growing which leads to great challenges for the management of these projects.

Construction practitioners have different perceptions on complexity within large construction projects. Practitioners from the same project or even the same organisation can have totally differing perceptions when it comes to project complexity. These different perceived complexities have appeared in research that focussed on the operationalisation of project complexity (i.e. the assessment of project complexity in real projects). The identification of these different perceived complexities led to questions on the origins of these perceived complexities and their consequences.

This research contributed to the management sciences of project management within large construction projects. Its objectives were to identify the different sources of perceived complexities, the implications of different perceived complexities for the project performance of large construction projects and the implications for project management within these projects.
The research furthermore elaborated on interventions dealing with project complexity in order to see if perceived complexities influenced project performance via the interventions. Interventions can be seen as actions that practitioners apply in order to deal with project complexity and that have the objective to influence this complexity.

The research was initiated by *Kennis In Het Groot* (KING) and the *Rijksprojectacademie* (RPA). These two organisations are knowledge institutes within the construction sector and aim to exchange knowledge between construction projects and to create new knowledge that helps these projects. They recently started the research on 'project complexity in the Dutch construction sector' as an application of this knowledge creation.
That research was designed and executed by Bosch-Rekveldt (2013) from the Delft University of Technology. She described the project complexity of construction projects in general terms and also identified different perceived complexities within projects: this identification requested a follow-up research since they were only identified, not explained. This thesis is the follow-up research on the research of Bosch-Rekveldt and contributes to the research of 'project complexity in the Dutch construction sector'.

Literature

A literature study was conducted for three reasons: (1) to see what is known about project complexity and how this research would embed within current knowledge; (2) to see how this research could describe perceived complexities in a meaningful way and (3) to see what is known about dealing with project complexity and how this research could confirm or reject these existing theories. These three topics will be elaborated below.

Literature defines project complexity with general terms and acknowledges the split between complicated and complex: complicated refers to the many components of a project that interrelate and complex refers to the unexpected things that happen due to this interrelation. Complex projects are believed to be complicated and complex at the same time.
Recent authors have exerted to operationalise this definition to make it useable in practice: they designed frameworks to assess the project complexity in construction projects. One of these authors is Bosch-Rekveldt (2011) who developed the TOE-framework: it uses 57 Technical, Organisational and External elements to assess project complexity and to make a complexity footprint of a specific project.

This research contributed to the literature that has the objective to operationalise the definition of project complexity. It supports a better understanding of the assessments of complexity within projects: by understanding how a perceived complexity is constructed by practitioners it is better understood how the assessment of project complexity by practitioners takes place.

This research used an adapted version of the Brunswik Lens Model (Brunswik, 1952) in order to describe the different perceived complexities of practitioners. This model is used to describe how organisms perceive their environment: they do so by selecting certain cues (i.e. components) of the environment and judge these cues which lead to a judgement on the environment. This research showed that the TOE-elements can function as cues that practitioners select and judge in order to come to their judgement on project complexity: this is their perceived complexity.

Literature identifies two approaches to deal with project complexity: the control-approach and the hands-off-approach. Theory argues that a combination of the two approaches results in the most effective approach to deal with project complexity. A management approach uses certain interventions to bring the approach into practice.
This research used the model of Best *et al.* (2013) to identify the specific interventions in practice. They distinct controlling interventions (aimed at controlling the project), connecting interventions (aimed to connect people and thoughts) and actuating interventions (aimed to push someone towards an action or decision). Controlling interventions contribute to the control-approach, connecting interventions to the hands-off-approach and the actuating interventions to both.

Methodology

The research can be seen as descriptive, explanatory and exploratory and uses an inductive approach based on qualitative data. Internal validation was done with triangulation, explanation building and sensitising concepts. External validation was done with literature and an expert meeting.

The research design consisted of an embedded multiple-case study. Five construction projects from the KING/RPA network were selected and functioned as cases; they contributed a total of 30 interviewees. These respondents were first asked to assess project complexity with a survey based on the TOE-framework (this survey was already designed by Bosch-Rekveldt). This survey resulted in three elements that were the most contributing elements to the complexity of the project according to the respondent. In-depth interviews were used to understand this top-3-list, its origins, its consequences and the way it was handled by the respondent.

The interview minutes were transformed with the help of descriptive research into three secondary data-sources: (1) case reports which provided an overview of all respondents within one case; (2) descriptions of the perceived complexities based on the adapted lens model and (3) a list of distilled interventions dealing with complexity.
Explanations for perceived complexities and their implications were found with the help of explanation building.

The results of the research were internally validated by confronting the participating project managers of the five cases with the results. They were also externally validated with literature and an expert meeting consisting of a debate on the findings of this thesis and in which approximately 30 construction practitioners participated.

Results

The five cases showed that there is a gap between the definitions of project complexity provided by theory and by practitioners: practitioners tend to base their perceived complexity on their degree of influence on project complexity and their perceived complexities can be split in either problem-focussed or challenge-focussed. This definition differs greatly from the definition provided by theory (based interrelating components which do so unexpected).

The five cases also showed a possible positive correlation between different perceived complexities and project performance: this led to the proposition that differing perceived complexities lead to better project performance than non-differing perceived complexities.

The data analysis led to an identification of origins of perceived complexities, an overview of applied interventions dealing with project complexity and a detailed description of implications of different perceived complexities. All three will be elaborated below.

A perceived complexity is created by the *selection* of certain elements of project complexity followed by a *judgement* of these elements (the elements are in this case the TOE-elements mentioned earlier). The sum of these separate judgements forms the perceived complexity. This research indicated four different sources for perceived complexities and these sources either contribute to the selection of TOE-elements or to the judgement of the TOE-elements.
Three of these four sources contribute to the selection of certain TOE-elements by practitioners to build a perceived complexity upon. These three sources are: (1) the perceived impact of an element and the influence of the practitioner on that element; (2) the experience of the practitioner and (3) the context of a project or contextual variables.
The fourth source contributes to the judgement of the TOE-elements: (4) the interests of the practitioner, which is in its turn influenced by the role and/or personal values.

These four sources all contribute in a certain degree to a perceived complexity but the contribution of each source can differ for each individual practitioner.

The list of encountered interventions dealing with project complexity was reflected against literature. This confirmed theories in their statement that practitioners apply a mix of connecting and controlling interventions. These two types of interventions contribute to the *control-approach* and the *hands-off-approach*. It was however also found that connecting interventions were sometimes used to enable controlling interventions and vice versa. This cross-application of intervention-types enabling other types has not been mentioned in researched theories and seems to be an addition to current literature.
The relation between perceived complexities and interventions dealing with complexity was also researched: it was found that there is a relation between them but the details of this relation were not found. It remains unclear if certain perceived complexities lead to certain interventions or that certain interventions (or: the feeling of influence) lead to certain perceived complexities. This is a topic for further research.

Different perceived complexities can contribute negatively to project performance if they remain unmanaged but they contribute positively to project performance if they are managed: the management of perceived complexities is referred to as perception-based management and this research argues that this perception-based management should become one of the core focuses in managing project complexity within large construction projects.

Interventions dealing with complexity were often applied in order to manage the collaboration with another party. This research acknowledged the Project Delivery Organisation, the contractor, the civil principals and the local stakeholders and advised the Project Delivery Organisation in the way they could manage their collaboration with these role-groups. This resulted in the following recommendations:

- *Steer on a clear mandate from civil principals*. This mandate must provide enough time, budget and space to execute the project.
- *Connect to the local stakeholders instead of controlling them*. PDOs apply too often a controlling approach. This controlling approach tries to *manage* the stakeholders but does not engage them in a connecting and fully transparent way: local stakeholders are not being truly involved in the project with the controlling approach. This is however desired and this research showed that the connecting approach is much more effective in increasing project performance.
- *Connect to the contractor but control if necessary*. The contractor needs a connecting approach but if the contractor fails to meet demands and expectations it should be engage with a much more controlling approach.

The research also found interventions dealing with project complexity that were mentioned by a large number of respondents: they were seen as general interventions to manage overall complexity. Five general interventions were mentioned: (1) interact *physically* with each other; (2) separate roles within organisations and individual people; (3) build informal networks to enable acting between rules and protocols; (4) find adequate people and (5) apply perception-based management.

Perception-based management is the management approach which focuses itself on the different perceived complexities of all involved practitioners. This research found four different ways of dealing with different perceived complexities: they can be ignored, eliminated, controlled or exploited. The latter two, control and exploitation, are part of the same model since first perceived complexities need to be controlled before they can be exploited. It is believed that this combination leads to the most improved project performance.
It consists of two stages: first all involved people have to agree on a shared mental model which centralises projects' interests and indicates the shared objectives of the project. Then all practitioners have to bring the shared mental model into action by basing their actions on the shared mental model.
Perception-based management contributes to project performance in two different ways: it contributes to a good collaboration with the shared mental model and it uses the untapped knowledge of all practitioners to apply project learning. This project learning is necessary because of the emergent and unpredictable character of large construction projects: they cannot be predicted and therefore need to be learned with the help of project learning.

This research acknowledged three principals that contribute to the application of perception-based management:

- *Create the appropriate preconditions*. These preconditions consist of awareness, the right ambiance, a good mandate from civil principals, the right kind of people and awareness of the consequences of certain contract types.
- *Create a shared mental model*. This shared mental model contains the common project goals and shared norms & values. It is used to give direction to the actions of the individuals within the project.
- *Focus on project learning*. Practitioners must feel free to question the shared mental model and thereby reshape the shared mental model. This enables the use of untapped knowledge (*unknown knowns*) because practitioners can continuously apply their knowledge by questioning the shared mental model. Perceived complexities can furthermore be used in applications of project management such as *Building Information Modelling* or *Joint Risk Finding*.

This description of perception-based management assumes awareness and respect for different perceived complexities. These assumptions were validated and confirmed in the expert meeting but this expert meeting also indicated that it was sometimes necessary to impose a perceived complexity to others for the sake of progress. This immediately shows a possible drawback of perception-based management: it might become too time-consuming. When to impose and when to apply perception-based management is a topic for further research: this research did not collect the right type of data to answer this question.

Another important limitation of this research was present in the explorative nature of it: the outcomes of this research lack sufficient data to formulate sound conclusions. The outcomes are therefore merely strong hypotheses which can lead to further research.
Yet another limitation was the representativeness of the cases for the Dutch construction industry: because all cases were member of the KING/RPA network they were more than average interested in new developments in the construction industry. The selected cases are therefore likely to be the 'top notch' of project management which could have led to a more promising current situation than average.
The last limitation is the lack of attention for strategic behaviour of actors; this could influence perception-based management severely but the data did not provide enough data to determine this influence.

Three directions for further research have been formulated:

- *The relation between improved project performance and perception-based management*. This research led to the hypothesis that project performance is positively influenced by perception-based management but future research must quantify and determine this relation. A case study can be designed to see if project performance and perception-based management are positively correlated. This would first need a more detailed description of perception-based management. This description can then be used to identify the applied type of perception-based management within the researched cases (ignorance, eliminating, controlling or exploiting) and to which degree they do so. The influence of strategic behaviour of individuals should also be regarded in this more detailed description.

By eventually linking the *type* and *degree of perception-based management* to *project performance* (which should be derived quantitative using an existing and proved method), it can be determined if the two concepts are indeed positively correlated.

- *The origins of perceived complexities*. This research found at least four sources and also proved that different sources contribute in different degrees to a perceived complexity. Future research can determine this contribution and use the used lens model more sophisticated to statistically prove the sources for the selection and judgement of TOE-elements. This would require a more detailed design of the lens model which is supported with statistical methods. Practitioners that function as units of analysis should be selected based on their role: by comparing practitioners with identical roles in different projects the research can determine the influence of the role of a practitioner.
- *Dealing with project complexity*. This research confirmed the existing theories that the management of project complexity must use a combination of the control-approach and the hands-off-approach. The cross-application of interventions between these two approaches and the question how practitioners can balance this approach, especially towards specific actor-groups, can be a topic for future research. This would require a case study in which projects that are already finished participate: it can then be reconstructed how project complexity was perceived, managed and what the objectives and actual effects of these interventions were.

  This research could at the same time research the relation between perceived complexities and applied interventions dealing with complexity: this research showed that there is a relation but it does not understand the specifics of this relation.

Samenvatting

Introductie

Projectcomplexiteit wordt vaak aangewezen als één van de hoofdoorzaken van het falen van grote bouwprojecten. Daarnaast is de heersende opvatting dat projectcomplexiteit binnen dit soort projecten groeit: dit heeft consequenties voor het management van deze projecten.

Professionals in de bouw hebben verschillende percepties over de projectcomplexiteit. Mensen die aan hetzelfde project werken, soms zelfs vanuit dezelfde organisatie, kunnen totaal verschillende percepties hebben over de projectcomplexiteit binnen het project. Deze verschillende percepties zijn aan het licht gekomen in onderzoek dat zich richt op het operationaliseren van projectcomplexiteit: dit onderzoek beoordeelt de complexiteit binnen bestaande bouwprojecten. De identificatie van deze verschillende percepties over projectcomplexiteit heeft tot vragen geleid over deze verschillen en hun gevolgen.

Dit onderzoek heeft bijgedragen aan management wetenschap die zich concentreert op het project management van grote bouw projecten. Het doel was om de verschillende bronnen van percepties over projectcomplexiteit te ontdekken, de consequenties van deze verschillende percepties te beschrijven en de consequenties voor project management binnen deze projecten aan te geven.
Het onderzoek heeft zich daarnaast ook geconcentreerd op de interventies die worden toegepast om om te gaan met projectcomplexiteit: het is onderzocht of verschillende percepties over projectcomplexiteit invloed hebben op de interventies die professionals toepassen om om te gaan met projectcomplexiteit en die tot doel hebben om de projectcomplexiteit te beïnvloeden.

Het onderzoek werd geïnitieerd door *Kennis in het Groot* (KING) en de *Rijksprojectacademie* (RPA). Deze twee organisaties zijn kennisinstituten in de bouwsector en hebben tot doel om kennis tussen bouwprojecten uit te wisselen en nieuwe kennis te genereren die deze projecten verder helpt. Binnen dit kader hebben zij recentelijk het onderzoek naar projectcomplexiteit in de Nederlandse bouw gestart.
Dat onderzoek is ontworpen en uitgevoerd door Bosch-Rekveldt (2013) van de Technische Universiteit Delft. Zij heeft projectcomplexiteit in de bouw in algemene lijnen beschreven en ook heeft zij verschillende percepties over projectcomplexiteit geïdentificeerd en beschreven: hieruit kwam de vraag naar vervolgonderzoek voort omdat het onderzoek de gepercipieerde complexiteiten alleen kon beschrijven en niet verklaren. Deze thesis is het vervolgonderzoek op dat onderzoek van Bosch-Rekveldt en draagt daarmee bij aan het grotere onderzoek naar projectcomplexiteit in de Nederlandse bouw.

Literatuur

Literatuuronderzoek werd gedaan omwille van drie redenen: (1) om te zien wat er bekend is over projectcomplexiteit en hoe dit onderzoek binnen die bestaande kennis past, (2) om te onderzoeken hoe percepties over projectcomplexiteit op een doordachte wijze omschreven konden worden en (3) om te weten wat er bekend is over de omgang met projectcomplexiteit en of dit onderzoek die theorieën zou bevestigen of verwerpen. Alle drie de onderwerpen worden hieronder behandeld.

Literatuur definieert projectcomplexiteit in globale termen en erkent het verschillen tussen gecompliceerd en complex: de term *gecompliceerd* refereert naar de vele componenten van een project die met elkaar in relatie staan, de term *complex* refereert naar de onverwachte dingen die gebeuren naar aanleiding van deze relatie. Complexe projecten zijn beide gecompliceerd en complex.

Recente auteurs hebben zich ingespannen om deze definitie werkbaar te maken voor de praktijk: zij hebben raamwerken ontworpen om de projectcomplexiteit in bouwprojecten te kunnen beoordelen. Eén van deze auteurs is Bosch-Rekveldt (2011) en zij heeft het TOE-framework ontworpen: dit raamwerk maakt gebruik van 57 elementen, verdeeld over de categorieën Technisch, Organisatorisch en Extern, om de complexiteit in een project te beoordelen en zodoende de complexiteitsvoetafdruk van een project te bepalen.
Dit onderzoek draagt bij aan die literatuur die tot doel heeft om de definitie van projectcomplexiteit te operationaliseren. Het leidt tot een beter begrip van de beoordelingen van projectcomplexiteit binnen bouwprojecten: door beter te begrijpen hoe een perceptie over projectcomplexiteit tot stand komt kan beter verklaard worden hoe een beoordeling door individuen van projectcomplexiteit precies plaatsvindt.

Dit onderzoek heeft een aangepaste versie van het lens model van Brunswik (1952) gebruikt om de percepties over projectcomplexiteit van individuen te beschrijven. Het model is gebruikt om te beschrijven hoe een organisme zijn omgeving percipieert: dat doen ze door bepaalde signalen (dus: projectonderdelen) van een omgeving te selecteren en die vervolgens te beoordelen. Deze beoordelingen leiden vervolgens tot een totale beoordeling van de projectcomplexiteit binnen bouwprojecten. Dit onderzoek heeft aangetoond dat de TOE-elementen gezien kunnen worden als deze ‘signalen’ die individuen selecteren en beoordelen om tot hun oordeel over de projectcomplexiteit te komen: dit is hun perceptie over projectcomplexiteit.

In de literatuur worden er twee manieren geïdentificeerd om om te gaan met projectcomplexiteit: de *controlerende aanpak* en de *vertrouwende aanpak*. Het wordt bepleit dat een combinatie van beide methoden een effectieve manier is om om te gaan met projectcomplexiteit. Deze methode wordt in de praktijk gebracht door middel van interventies.
Dit onderzoek gebruikt het model van Best *et al.* (2013) om specifieke interventies die de praktijk gebruikt te identificeren. Zij onderscheiden controlerende interventies (met als doel om het project te controleren), verbindende interventies (met als doel om mensen en ideeën te verbinden) en bedienende interventies (met als doel om iemand richting een actie of besluit te bewegen). Controlerende interventies corresponderen met de controlerende aanpak, verbindende elementen met de vertrouwende aanpak. Bedienende interventies dragen bij aan beide aanpakken.

Methodologie

Het onderzoek is beschrijvend, verklarend en verkennend en maakt gebruikt van een inductieve aanpak gebaseerd op kwalitatieve data. Interne validatie gebeurde middels triangulatie, systematische constructie van verklaringen en het gebruik van gevoelsmatige keuzes gebaseerd op de dataset. Externe validatie gebeurde middels een expert bijeenkomst.

Het onderzoek maakt gebruikt van een geïntegreerde meervoudige case studie. Vijf bouwprojecten van het KING/RPA netwerk werden geselecteerd en functioneerden als cases: in totaal hebben zij 30 geïnterviewden aangedragen voor het onderzoek. Deze respondenten is eerst gevraagd om een enquête in te vullen die gebaseerd was op het TOE-framework (deze enquête is ontworpen door Bosch-Rekveldt). Deze enquête resulteerde in drie elementen die de respondent als meest bijdragend aan de projectcomplexiteit percipieerde: een persoonlijke top-3 dus. Diepte interviews zijn vervolgens afgenomen om deze top-3 te begrijpen: zowel de oorsprong als de consequenties als de manier waarop de respondent omging met deze drie elementen.

De notulen van de interviews zijn vervolgens verwerkt in drie secundaire data bronnen middels beschrijvend onderzoek: (1) project verslagen die een overzicht gaven van alle respondenten binnen eenzelfde case, (2) beschrijvingen van de percepties over projectcomplexiteit gebaseerd op het ontworpen lens model en (3) een lijst van gebruikte interventies om om te gaan met projectcomplexiteit.
De uitleg voor de verschillende percepties over projectcomplexiteit en hun consequenties werd geformuleerd met behulp van het systematisch construeren van een verklaring.

De resultaten zijn intern gevalideerd door de resultaten voor te leggen aan de deelnemende projectmanagers. De resultaten zijn ook extern gevalideerd binnen de literatuur en een

expert bijeenkomst. Deze bijeenkomst bestond uit een debat over de resultaten en werd bijgewoond door ongeveer 30 professionals uit de bouwsector.

Resultaten

De vijf onderzochte casussen laten zien dat er een verschil zit in de definitie van projectcomplexiteit zoals die gebruikt wordt door de theorie en door de praktijk: de professionals in de bouw baseren hun definitie op de mate van invloed die zij hebben op de projectcomplexiteit en hebben ofwel een *probleemgeoriënteerde* ofwel een *uitdaginggeoriënteerde* perceptie. Deze definitie verschilt in grote mate van die van de theorie (die dus gebaseerd is op de relatie tussen componenten en de onverwachte dingen die hieruit voortkomen).

De vijf casussen laten ook een positieve correlatie zien tussen de projectprestatie en verschillende percepties over complexiteit: dit heeft geleid tot de stelling dat verschillende percepties over projectcomplexiteit leiden tot betere projectprestaties dan wanneer de verschillende percepties over projectcomplexiteit niet verschillen.

Data-analyse leidde tot het identificeren van verschillende bronnen die bijdragen aan een perceptie over projectcomplexiteit, een overzicht van toegepaste interventies om om te gaan met projectcomplexiteit en een gedetailleerde beschrijving van de gevolgen van verschillende percepties over projectcomplexiteit. Alle drie zullen hieronder toegelicht worden.

Een perceptie over de projectcomplexiteit wordt gevormd door de selectie van bepaalde elementen die vervolgens beoordeeld worden (elementen zijn in dit geval de eerder genoemde TOE-elementen). De som van al deze beoordelingen vormt vervolgens de totale perceptie over de projectcomplexiteit. Dit onderzoek heeft vier bronnen aangewezen die bijdragen aan deze percepties en deze bronnen dragen dus bij aan ofwel de *selectie* van een element ofwel de *beoordeling* van een element.
Drie van de vier geïdentificeerde bronnen dragen bij aan de *selectie* van een bepaald TOE-element. Deze bronnen zijn: (1) de gepercipieerde impact van een element en de invloed die het individu heeft op dit element, (2) de ervaring van een individu en (3) de context van een project (of: contextvariabelen).
De vierde bron draagt bij aan de beoordeling van deze elementen: (4) de belangen van een individu, welke op hun beurt weer beïnvloed worden door de rol en/of persoonlijke waarden van het individu.

Het is vastgesteld dat alle vier de bronnen bijdragen aan de vorming van een perceptie over projectcomplexiteit maar het is ook vastgesteld dat de bijdrage van een specifieke bron per individueel persoon kan verschillen.

Bestaande literatuur werd gereflecteerd aan de lijst van gevonden interventies om om te gaan met projectcomplexiteit. Deze reflectie bevestigde de bestaande theorie dat projectcomplexiteit wordt gemanaged door een mix van controlerende en verbindende interventies. Deze twee types van interventie dragen bij aan respectievelijk de controlerende aanpak en de vertrouwende aanpak. Het onderzoek heeft echter ook aangetoond dat controlerende interventies soms werden gebruikt om de vertrouwende aanpak mogelijk te maken en vice versa. Deze *crossapplicatie* van interventies (die dus de andere aanpak mogelijk maken) is niet gevonden in de onderzochte literatuur en lijkt zodoende een toevoeging te zijn op die bestaande literatuur.
Er werd ook onderzoek gedaan naar de relatie tussen een perceptie over projectcomplexiteit en de gepleegde interventies om om te gaan met die complexiteit. Het is vastgesteld dat die relatie bestaat maar de details van deze relatie zijn niet gevonden. Het blijft onzeker of een bepaalde perceptie leidt tot een bepaalde interventie of dat een bepaalde interventie (of: een gevoel van invloed) leidt tot een bepaalde perceptie. Dit is een onderwerp voor vervolgonderzoek.

Verschillende percepties over projectcomplexiteit kunnen negatief bijdragen aan de projectprestatie wanneer zij niet gemanaged worden. Wanneer zij echter wel gemanaged worden, kunnen ze juist positief bijdragen aan de projectprestatie: het management van verschillende percepties over projectcomplexiteit wordt in dit onderzoek aangeduid als *management op basis van percepties*. Dit onderzoek betoogt dat management op basis van

percepties een belangrijke kern zou moeten vormen in het management van projectcomplexiteit binnen grote bouwprojecten.

De gevonden interventies die omgaan met projectcomplexiteit werden vaak toegepast om de samenwerking met een andere partij binnen het project te managen. Dit onderzoek onderscheidde de projectorganisatie, de aannemer, de maatschappelijke opdrachtgevers en de lokale partijen. Het adviseert uiteindelijk de projectorganisatie over de omgang met deze overige drie partijen. Dit resulteerde in de volgende aanbevelingen:

- *Stuur aan op een helder mandaat van maatschappelijk opdrachtgevers*. Dit mandaat moet genoeg tijd, budget en ruimte bieden om het project uit te kunnen voeren.
- *Verbind met lokale partijen in plaats van hen te controleren*. Project organisaties passen nog te vaak een controlerende aanpak toe richting lokale stakeholders. Deze aanpak probeert de lokale partijen te managen maar benadert ze niet op een volledig verbindende manier: lokale partijen worden niet oprecht betrokken in een project met de controlerende aanpak. Dit onderzoek toont echter aan dat lokale stakeholders graag juist verbindend benaderd willen worden en dat deze aanpak ook meer effectief is in het verbeteren van de projectprestatie.
- *Verbind met de aannemer maar controleer wanneer nodig*. De aannemer heeft een verbindende aanpak nodig maar wanneer de aannemer niet aan de vraag en verwachtingen van de projectorganisatie blijft voldoen dient de controlerende aanpak meer gehanteerd te worden.

Het onderzoek heeft ook een aantal interventies gevonden dat door een groot aantal respondenten genoemd is: zij worden gezien als algemene interventies die bruikbaar zijn om om te gaan met de grote lijnen van projectcomplexiteit. Er zijn vijf interventies vaak genoemd: (1) fysiek contact is belangrijk in communicatie, (2) scheid rollen zoveel als mogelijk binnen organisaties en individuen, (3) bouw informele netwerken zodat het mogelijk wordt om tussen de regels en protocollen door te laveren, (4) vind geschikte mensen en (5) pas management op basis van percepties toe.

Management op basis van percepties is een aanpak die zich concentreert op de verschillende percepties over projectcomplexiteit van alle betrokken professionals in een project. Dit onderzoek heeft vier manieren gevonden om om te gaan met verschillende percepties over projectcomplexiteit: ze kunnen *genegeerd* worden, *geëlimineerd* worden, *gecontroleerd* worden of *geëxploiteerd* worden. De laatste twee manieren, *controle en exploitatie*, zijn onderdelen van dezelfde tweetrapsraket: eerst volgt controle waarna vervolgens verschillende percepties geëxploiteerd kunnen worden. Het is aannemelijk dat deze aanpak van alle aanpakken leidt tot de meest verbeterde projectprestatie.
De aanpak bestaat uit twee gedeeltes: eerst moeten alle betrokkenen een gedeeld mentaal model overeen komen dat de projectbelangen centraliseert en de doelen van het project helder formuleert. Vervolgens moeten alle individuen dit gedeelde mentale model in de praktijk gaan toepassen door hun acties te baseren op dit model.
Management op basis van percepties draagt bij aan de projectprestatie op twee manieren: het verbeterd de samenwerking tussen individuen door het gedeelde mentale model en het maakt gebruikt van de ongebruikte kennis van individuen om zo het project te begrijpen en te leren. Dit begrijpen en leren binnen een project is noodzakelijk omwille van het onvoorspelbare karakter van projectcomplexiteit: projecten kunnen niet voorspeld worden en dienen zodoende in de praktijk, bijna spelenderwijs, begrepen en geleerd te worden.

Dit onderzoek erkent drie principes die bijdragen aan de toepasbaarheid van *management op basis van percepties*:

- *Creëer de juiste randvoorwaarden*. Deze randvoorwaarden bestaan uit bewustzijn over de verschillen, de juiste sfeer, een helder mandaat van de maatschappelijk opdrachtgever, het juiste type mensen en het bewustzijn van de gevolgen van een bepaald contract type.
- *Bouw een gezamenlijk mentaal model*. Dit mentale model bevat de doelen van het project en de gedeelde normen en waarden binnen het team. Het wordt gebruikt om de acties van individuen richting te geven binnen een project.
- *Concentreer op het leren en begrijpen van het project*. Individuen moeten zich daarom vrij voelen om het mentale model ter discussie te stellen en dit model op die manier te herontwerpen. Dit maakt het gebruikt van verborgen kennis mogelijk. Verschillende percepties over projectcomplexiteit kunnen daarnaast ook nog gebruikt worden in applicaties zoals BIM en JRF (*"gezamenlijke risico allocatie"*).

Bovenstaande beschrijving van management op basis van percepties gaat er vanuit dat er begrip en respect bestaat in de praktijk voor verschillende percepties over projectcomplexiteit. Deze aannames zijn gevalideerd en bevestigd in een expert bijeenkomst maar hier werd ook duidelijk dat het soms noodzakelijk is om een perceptie over projectcomplexiteit op te leggen aan anderen omwille van de voortgang van het project. Dit laat een mogelijk nadeel zien van *management op basis van percepties*: het kan teveel tijd kosten in een project. Wanneer een perceptie opgelegd moet worden en wanneer *management op basis van percepties* kan plaatsvinden is een onderwerp voor vervolgonderzoek omdat dit onderzoek daarvoor niet de benodigde data heeft verzameld.

Een andere belangrijke beperking van dit onderzoek lag in het verkennende karakter van het onderzoek: de uitkomsten van het onderzoek zijn niet op voldoende data gebaseerd om de juistheid van de uitkomsten te kunnen garanderen. De uitkomsten van dit onderzoek moeten daarom gezien worden als sterke hypotheses die gebruikt kunnen worden in eventuele vervolgonderzoeken die wellicht een meer kwantitatief karakter kunnen hebben.
Een derde beperking van het onderzoek was de scheve afspiegeling van de geselecteerde cases binnen de Nederlandse bouwsector: omdat alle projecten lid waren van het KING/RPA netwerk kan het aangenomen worden dat deze projecten meer dan gemiddeld geïnteresseerd waren in nieuwe ontwikkelingen binnen de industrie. Het valt daarom te verwachten dat de geselecteerde projecten de bovenkant vormen van vooruitstrevend project management in de Nederlandse bouwsector en zodoende kan de huidige situatie binnen de sector te rooskleurig zijn voorgesteld.
De laatste beperking van het onderzoek is het gebrek aan aandacht voor strategisch gedrag van individuen: dit gedrag kan *management gebaseerd op percepties* sterk beïnvloeden en wellicht zelfs ondermijnen. De beschikbare data bood echter geen ruimte om dit fenomeen te onderzoeken binnen dit onderzoek.

Er zijn drie onderzoeksrichtingen aangewezen voor vervolgonderzoek:

- *De correlatie tussen een positieve projectprestatie en management gebaseerd op percepties*. Dit onderzoek heeft geleid tot de hypothese dat de prestaties van een project positief worden beïnvloed wanneer management gebaseerd wordt op percepties. Vervolgonderzoek moet deze relatie kwantificeren en vaststellen. Een case studie kan ontworpen worden om te zien of de twee begrippen positief gecorreleerd zijn. Hiervoor is ten eerste een meer gedetailleerde omschrijving van management op basis van percepties nodig: deze beschrijving kan vervolgens gebruikt worden om te bepalen welk type perceptie-management de onderzochte casussen hanteren (negeren, elimineren, controleren of exploiteren) en in welke mate ze dit doen. De invloed van strategisch gedrag door individuen zou ook meegenomen moeten worden in deze gedetailleerde beschrijving.
  Door uiteindelijk het type perceptie-management en de mate waarin dit gebeurt te koppelen aan de projectprestatie (die kwantitatief bepaald zou moeten worden aan de hand van een bestaande en bewezen methode) kan bepaald worden of de twee begrippen inderdaad positief gecorreleerd zijn.
- *De bronnen van percepties over projectcomplexiteit*. Dit onderzoek heeft minsten vier bronnen aangewezen voor percepties over projectcomplexiteit en heeft ook aangetoond dat deze vier bronnen in verschillende mate bijdragen aan een perceptie, afhankelijk van het individu. Vervolgonderzoek kan deze bijdrage per bron bepalen en met behulp van het lens model kunnen bronnen bijdragend aan de selectie en beoordeling van TOE-elementen geraffineerder en statistisch bewezen worden. Dit vereist een beter ontwerp van het lens model waarin de statistische mogelijkheden van het model benut worden. De professionals die geselecteerd worden voor het onderzoek dienen geselecteerd te worden op basis van hun rol: door individuen met dezelfde rol in verschillende projecten te vergelijken kan de invloed van de rol op de bijdrage van iedere bron bepaald worden.
- *Omgaan met projectcomplexiteit*. Dit onderzoek heeft bestaande theorieën bevestigd in hun opvatting dat de omgang met projectcomplexiteit een mix is van de *controlerende* aanpak en de *vertrouwende* aanpak. De crossapplicatie van interventies tussen de twee aanpakken en de vraag *hoe* professionals de beide aanpakken kunnen balanceren is een onderwerp voor vervolgonderzoek. Dit vereist een case studie waarin reeds afgeronde projecten onderzocht worden: de gepercipieerde complexiteit kan dan gereconstrueerd worden samen met de interventies die gepleegd zijn om om te gaan met die complexiteit. Ook kunnen de initiële doelen van de interventie en de uiteindelijke effecten gereconstrueerd worden.

Dit onderzoek zou uiteindelijk ook de relatie tussen percepties over projectcomplexiteit en toegepaste interventies kunnen onderzoeken: dit onderzoek heeft aangetoond dat die relatie bestaat maar het is nog onduidelijk hoe die relatie precies wordt ingevuld.

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1. Introduction

> **"True simplicity is derived from so much more than just the absence of clutter and ornamentation. It's about bringing order to complexity„**
>
> **John Ive, Senior Vice President Design at *Apple***

Apple, with an expected revenue of over $30 billion in 2013 and hundreds of millions products sold globally, is one of the biggest companies on the planet. The quote of John Ive, head design at Apple, expresses his feelings on the explanation of the success of its products and its designs: bringing order to complexity. This one view, expressed into two sentences, indicates an important opinion about complexity: it puts the management of complexity at the core of the company.

Apple is not the only business that acknowledges complexity in its core business: complexity is a phenomenon of which the construction business is becoming, along with other businesses, more and more aware since construction projects are believed to have become more complex in the recent past. Contemporary project management focuses itself therefore increasingly on the management of complexity and project complexity is a hot item in project management literature (Whitty & Maylor, 2009; Koppenjan *et al.*, 2011).

Construction projects in the Netherlands are often ordered by governmental organisations (Armstrong *et al.*, 2013) and can consist of projects like non-residential projects (museums, hospitals, energy plants), dry infrastructure projects (roads, railroads, rail stations) or wet infrastructure projects (locks, harbours, channels).
The assignment for these projects often comes from political decision-makers, such as the house of parliament, the national government, provinces or municipalities. Organisations like *ProRail* (the department of rail infrastructure) and *Rijkswaterstaat* (the department of public works) are examples of organisations responsible for the execution of these projects: they need to detail the project and tender the project to a private partner who becomes responsible for the design, construction, maintenance and/or operation of it. These private partners are often contractors.

The role of projects within society has become increasingly more important: organisations use projects more and more to execute their objectives. This is called *projectification* and projectification has even become so important that the core focus of several organisations is concentrated on the management of multiple projects at the same time. This is called *programmafication*: the programmafication of society is believed to be still ongoing (Maylor *et al.*, 2006).

At the same time the public attention for these projects and especially their failures has grown significantly. Examples like the *Betuweroute*, *Noord/Zuid line* and *HSL-south* became known for their huge time and budget overruns which led to increased public awareness of the importance of construction projects to society. A more recent example is the Dutch high-speed train Fyra: its failure will cost society severely and has led to much attention in the public debate.
Complexity is often accused as being the cause of this failure (Whitty & Maylor, 2009) and is referred to as *project complexity*.

This thesis focuses itself on the management of this project complexity within *Large Construction Projects* (*LCPs*), executed in the Netherlands.
So what makes a construction project a LCP? LCPs are construction projects that are large in terms of Capital Expenditure (*CAPEX*), number of involved internal actors and/or number of involved external stakeholders. The term 'large' is deliberately not specified because it is

not the intention of this thesis to define a specific threshold. Large must be seen as 'above average'.
LCPs furthermore have a public authority as client and the public interest is therefore a component within these projects. Because these projects are paid for with public money, it is important to transparently allocate the financials resources within the LCPs. It also means that projects have to be executed with maximized cost-efficiency and have to do so in a transparent way. The involvement of public parties results in a different kind of project than projects in which only private parties participate.
Examples of extreme LCPs in the Netherlands are the earlier mentioned *Betuweroute*, *the Delta Works*, *the Noord/Zuid line* and the *HSL-south*. These projects are examples of the upper limit of LCPs and therefore state the norm: they can be called *megaprojects*. But projects that are less 'mega' also can be classified as LCPs: the cases treated in this research will show that much smaller projects (in terms of CAPEX) can be still very complex due to the number of involved stakeholders and can therefore also be classified as LCPs.

This thesis will look at complexity within LCPs from the perspective of the Project Delivery Organisation (*PDOs*). These PDOs are the organisations that are responsible for the execution of the LCPs. They can be seen as both the end-station of the process of political decision-making and the starting-point for the physical construction of a project. They are the vital link between politics and practice and therefore crucial in the management of LCPs. The results of this thesis will be tailor-made for these PDOs, which means that conclusions and advises will be focussed on the PDO rather than other important parties within LCPs.

1.1. The challenges of the Project Delivery Organisation

To better understand the influence of project complexity on PDOs and project performance the following section will mention some examples of complex elements that PDOs need to deal with in LCPs.

An example of this challenge is found in the use of integrated contracts and Public-Private-Partnerships (PPP). Both contract types are relatively young: the first large project delivered with an integrated contract was the *Maeslantkering* in 1997 (KING, 2013) and the PPP-contracts did not found true ground in the Netherlands until the second PPS-wave in 2002 (Klijn & Twist van, 2007).
These types of contracts involve the market much more than traditional contracts and make use of the knowledge and skills of private parties. Private partners are due to the contracts often responsible for both the design *and* the construction of LCPs (opposed to traditional contracts where private parties provide either the design *or* the construction). They can even become responsible for financing, maintaining and operating the LCPs, depended on the situation.
In this shift of responsibilities from the PDO to the contractor lies a fundamental challenge: public interests need to be served by private partners resulting in a tension between the primary interest of the public (quality) and the primary interest of the companies delivering the projects (profit). PDOs have to be able to deal with this tension and must find the balance in delivering a qualitative and cost-effective project without ignoring the necessary profit margin for contractors.

Another example of a challenge for PDOs is the growing importance of local stakeholders in both the design-phase and the execution-phase of the project. These local stakeholders (consisting of actors like local residents, NGOs, environmental organisations, etc.) can influence project performance severely by means like juridical procedures: these procedures often cost time and money thereby delay projects or even alter projects. But local stakeholders can for example also influence involved decision-makers which could result in an altered assignment for the PDO, maybe even during the construction phase. It became therefore necessary, due to this influence, that PDOs take all important local stakeholders into account. Their number is also likely to grow: projects are more and more executed within urban areas resulting in more involved local stakeholders.

These two examples show that PDOs have to take many things into account while delivering LCPs: it are examples of the growing complexity within LCPs and it is believed that complexity in these projects will continue to grow (Romein *et al.*, 2003; Thomas & Mengel, 2008).
This explains the increased attention within literature and scientific research for the phenomenon of project complexity. Research often tries to understand project complexity

and, even more important, desires to contribute to the knowledge on project management so that PDOs can deal with this project complexity.

1.2. Research on project complexity and project management

The growing complexity within LCPs has led to scientific research on this topic with the objective to understand and manage project complexity. This is done by scientific research on this topic, but also through the exchange of knowledge and experiences within the construction sector. This exchange of knowledge is the objective of multiple knowledge institutes and *Kennis In het Groot (KING)* is an example of such an organisation. KING was founded in 2008 by Rijkswaterstaat, ProRail and the municipality of Amsterdam with the objective to exchange knowledge between complex LCPs and to create knowledge that could be used in the construction industry. It is their belief that the management of complex projects does not only consists of project control (i.e. controlling time, scope and budget), but also of more 'soft issues' like people and processes.
The *RijksProjectAcademie* (*RPA*) is a comparable initiative and was started in 2009 by, among other organisations, Rijkswaterstaat. It aims at the supply of knowledge, the creation of knowledge and the exchange of knowledge. Several construction projects join within their program. Very recently KING and the RPA decided to join together in an alliance.
KING and the RPA started research on project complexity in cooperation with the Delft University of Technology with the aim to gain better understanding of project complexity within LCPs from a scientific perspective. This research was conducted by Marian Bosch-Rekveldt, who developed the TOE-framework (Bosch-Rekveldt, 2011) and used this framework to assess the project complexity within LCPs (Bosch-Rekveldt, 2013).

The TOE-framework is a framework derived from practice and can be used to answer the question of what an individual judges as complex within a project. The framework consists of 57 elements divided over three categories: Technical, Organisational and External elements. It is used to assess the 'complexity footprint' of a project bottom-up, so from a practitioners' perspective.

In order to assess the experienced project complexity within LCPs she asked 164 respondents divided over 35 construction projects from the KING/RPA network to judge the 57 elements on project complexity with the help of a survey. This resulted in the identification of four overall aspects that contributed to general project complexity within LCPs:

- Complexity due to time/dynamics
- Complexity due to interfaces
- Complexity due to the lack of resources
- Complexity due to external influences

This assessment of project complexity with the survey based on the TOE-framework provided the starting point for this research.

1.3. Problem formulation

Although the respondents in the research of Bosch-Rekveldt (2013) identified four general groups of elements that drives project complexity within the projects, the differences in the answers between the respondents were considerable and asked for an explanation.
These differences were predicted and with the help of the answers on the survey they became concrete and determinable: the survey provided insights into the differences.

The respondents showed in other words different *perceived complexities*, not only between different projects but also within the same projects and even within the same organisations. These different perceived complexities were observed and it was desirable to know what the causes of these different perceived complexities were and what their consequences were for the project performance of LCPs

There was another question besides the desire to understand the different perceived complexities: how could PDOs manage the complexity within the project? Theory provides several management approaches on project complexity (some of them will be described in chapter two) but it is unclear which management techniques are applied in practice.
There is furthermore little known about the specific interventions that deal with project complexity (Whitty & Maylor, 2009) and one of the first steps to identify specific

interventions was taken by Best, *et al.* (2013): they however too indicated that more research on this topic is necessary.

So there is a demand from construction practitioners for two types of knowledge: (1) about different perceived complexities and (2) about interventions to deal with this project complexity. This demand is formulated by KING/RPA, but the attention for the more 'soft skills' also grows in project management literature (Cicmil *et al.*, 2006; Cooke-Davies *et al.*, 2007; Favari, 2012). This rising interest in literature can be explained with the growing complexity within LCPs (Romein, *et al.*, 2003; Thomas & Mengel, 2008). Management approaches therefore need to adapt to this growing complexity (Vidal *et al.*, 2011), and education of project management needs to adapt accordingly (Thomas & Mengel, 2008; Whitty & Maylor, 2009).

Summarised: there is very little known in theory about perceived complexities and possible specific interventions to deal with project complexity which shows the importance of this research. This also made this research quite explorative in its nature which made it difficult to design predefined frameworks and answer-designs: this will be further elaborated in chapter three. It is first important to formulate research objectives and questions.

1.4. Research objectives and question

The objective of this research is to understand perceived complexities and its implications on the project performance of LCPs. By identifying the causes of a perceived complexity it can be better understood how construction practitioners judge the project complexity within LCPs: the project management of complex LCPs can be optimized by understanding the consequences of these different perceived complexities.

This research especially focuses itself on the relation between perceived complexities and interventions to deal with complexity: by doing so the consequences of different perceptions become apparent within LCPs.

The research objectives can be split into four different objectives which all together contribute to the main research objective. The four objectives are described below.

- Understanding perceived complexities
- Understanding the relations between perceived complexities and interventions dealing with project complexity
- Understanding the implications of different perceived complexities on project performance
- Formulate the implications of different perceived complexities for project management

The research focuses itself on the perspective of the PDO: by equipping these PDOs with knowledge on different perceived complexities the research contributes to the improvement of management of project complexity since it are the PDOs that form the core of project management within LCPs.
It is also an objective to enrich literature on project management: the research looks at project complexity and project management from a practitioners' perspective by applying a bottom-up approach. This bottom-up approach provides a useful addition and reflection on the available scientific knowledge on these subjects, certainly concerning the Dutch construction industry.

It is explicitly not the objective of this research to formulate a theoretical, general definition of project complexity within LCPs. By understanding the phenomenon of different perceptions and focussing on consequences rather than definitions the research aims to improve project management and therefore project performance.

These research objectives lead to the following research question:

> **How do different perceived complexities impact project performance of LCPs and what are the implications for the project management of LCPs?**

The main research question will be answered with the help of seven sub-questions which will be answered in chapters five, six and seven.

A. How can perceived complexities be described?
B. How do the different perceived complexities originate?
C. How can perceived complexities of construction practitioners be categorised?
D. What is the link between perceived complexities and interventions dealing with project complexity?
E. How do perceived complexities affect interventions dealing with complexity?
F. What are the implications of different perceived complexities on project performance?
G. What do different perceived complexities mean for project management?

1.5. Reading guide

Chapter two, *theoretical background*, will provide the necessary theoretical framework in order to understand the context and knowledge on the most important concepts of this research. This knowledge was used in order to formulate the necessary propositions for this research.

Chapter three, *methodology*, explains and defends the methodology used to perform the research. By combining the problem formulation from chapter one and the knowledge of chapter two together with literature on methodology, the research design was made and based on a case study.

Chapter four, *set-up of the case studies*, shows the detailed design of the embedded multi-case study and the methodology used to analyse the data.

Chapter five, *results of the case studies*, displays the results of the cases in the form of detailed case reports. A reflection on each case is also provided in this chapter.

Chapter six, *results of the data analysis*, gives the results of the data analyses performed on the data. It illustrates the use of explanation building in order to build hypotheses used to explain certain phenomena and shows the results of descriptive research which is used for, among other objectives, the description of encountered interventions dealing with complexity.

Chapter seven, *results and discussion*, discusses the results gained from chapters five and six. It validates the outcomes of the research in three ways: internal validation by confronting the participating project managers with the outcomes (1), external validation by reflecting the outcomes in literature (2) and external validation by discussing the outcomes in an expert panel (3). This expert panel consisted of approximately 30 construction practitioners and was organised as a debating-event of KING.

Chapter eight, *conclusions and recommendations*, combines the results and gives an answer on the main research question. The chapter is concluded with a number of indications for further research.

2. Theoretical framework

The previous chapter introduced several scientific topics on which knowledge and theories already exist. This chapter functions as an elaboration on these topics in order to better understand the framework in which this research takes place.

Theoretical research was conducted on three specified topics so that this knowledge could be used throughout the research. These three topics are summed up below and form the three sections of this chapter. The objective that the three topics serve is also described.

- The definition of *project complexity* (§2.1). Theory about this topic provides the necessary distinction between simple, complicated and complex projects and leads to a clear formulation of what is considered as complex by existing theory. This section also indicates how this research is embedded into the existing knowledge about project complexity.
- A better understanding of *perceptions* (§2.2). Knowledge on this topic leads to a better understanding of perceptions within organisms and provides a framework which can be used in the research to describe different perceived complexities
- An assessment of known *project management approaches to deal with project complexity* (§2.3). One objective of this research is to identify and classify interventions dealing with project complexity and in order to do so this chapter provides the knowledge to build a framework of encountered PM approaches in literature.

It is not the aim of this research to provide a comprehensive overview of all important literature: it merely uses theory to meet the described objectives. Research focussed on recent theories so that this research could be embedded within these recent theories.
Literature that is used in the section about perceptions functions merely as an introduction in the field of cognitive psychology: it is therefore less actual but still relevant.

2.1. Project complexity

Project complexity is the general term used to identify complexity within projects and is a phenomenon which is not limited to construction projects but construction projects are certainly an applicable field for project complexity (Baccarini, 1996). This complexity is seen as a major contributor to project failure of LCPs (de Ridder, 1994; Baccarini, 1996; Thomas & Mengel, 2008; Koppenjan*, et al.*, 2011; Favari, 2012) and is therefore richly treated within project management literature.

But what is project complexity? Literature defines several types of project complexity which are understood by the author as two major types of definitions: definitions based on the *systems-view* and a definition based on the *edge-of-chaos-view*. Both are explained in the following.

The first view, the systems-view, applies to the theory in which projects are seen as systems. A system is created when multiple components are connected to each other and create a result which is greater than the sum of the individual components. This phenomenon was first observed in the field of biology (de Ridder, 1994) but is since then applied in geology, astronomy, chemistry and meteorology (Thomas & Mengel, 2008).
Complex systems are not clear to define but are traditionally and generally seen as systems where there is a lot of interrelation and interconnection between the different components of a system (Thomas & Mengel, 2008). This implicates that all systems have a degree of 'how complex the system is' (since every system has at least two components interrelating and connecting): the term *complexity* refers to this degree of how complex a system is and states that the complexity of a system can be benchmarked with other systems on the same ruler (Whitty & Maylor, 2009).

The second view, the edge-of-chaos-view, gained increased awareness when complexity theories were applied to organisational science (Thomas & Mengel, 2008) since organisational sciences do not only wish to contemplate complexity but also want to manage this complexity (Favari, 2012). This brought a more modern view on complexity forward: this more modern view regards project complexity as the ability of a system to adapt and organize itself. Complex systems are open, chaotic, self-organizing and interdependent (Thomas & Mengel, 2008; Favari, 2012). Cooke-Davies*, et al.* (2007) add the more generic view that modern research on project complexity tries to understand how order and structure arises from chaotic and uncertain situations, and how chaos arises from order and structure.

Summarised: complex projects consist of multiple components which interrelate with each other (traditional view) and do so unexpected (modern view). These two main views on project complexity can be used to better understand the definitions in literature which are treated below in order to come to a definition of project complexity which can be used in the research.
Besides this general definition this section also makes clear how the research on perceived complexities fits into existing knowledge of project complexity. All used literature is therefore specifically scanned on any mentioning's of different perceptions within the definitions of project complexity.

Baccarini (1996) argues that until the 90s no clear definition of project complexity was given. He defines project complexity, especially within construction projects, in terms of *differentiation* (the number of different elements) and *interdependency* (the matter to which extend these elements interrelate with each other): this definition corresponds with the traditional view on complexity. He furthermore emphasizes the fact that the type of project complexity makes all the difference in a definition since project complexity can apply to several project dimensions, such as: the organisational dimension, technical dimensions, environmental dimensions, decision making processes and sub-systems. He finally concludes that an operational step is necessary in defining project complexity but does not mention different perceptions whatsoever.

Williams (1999) is one of the first encountered authors that introduce the modern view on project complexity: he defines *uncertainty* next to *structural uncertainty*. This structural uncertainty refers to the traditional view on project complexity (since it refers to interrelating components) and the introduced uncertainty refers to the unexpected behaviour of projects and therefore more to the modern view on project complexity. This uncertainty exposes itself within the projects' goals and methods. There are no mentions of different perceived complexities in his research.

Thomas and Mengel (2008) acknowledge the two main views and add that practitioners often refer to complexity from the systems-view rather than the edge-of-chaos-view. Thomas and Mengel however focus their definition on the latter, since projects in practice are becoming increasingly more dynamic and unstable and they believe that it is this complexity that needs attention.
They base their definition of complexity on three different approaches: the chaos theory, dissipative structures and adaptive systems: the first theory refers to the ability of a project complexity to change over time, the second to the dynamics between the stable and unstable point of projects and the third to the ability of projects' parts to learn and adapt to complexity autonomously.
They do not mention any form of perceived complexity explicitly but their notion that practitioners often indicate different types of complexity than the theoretical sources might implicate different perceived complexities.

Whitty and Maylor (2009) warn for the fact that projects are too often called 'complex' while they are actually not: *complexity* is merrily a degree of *complex* and has therefore different levels.
To indicate whether a project is truly complex the Structural Dynamic Interaction matrix (*SDI*, figure 2.1) is used. This matrix distinguishes structural and dynamic projects: dynamic projects change over time due to complexity; structural projects do not change. It also distinguishes independent parts of the project or interacting parts of the project: interacting parts of the project cause other parts to change, independent parts do not.

Whitty and Maylor classify a project as 'truly complex' if they are a type-4 project, so a dynamic and interacting project. They do not mention any reference to perceived complexities of practitioners within projects.

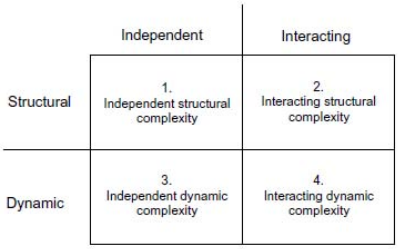


FIGURE 2.1 SDI MATRIX TO ASSESS COMPLEXITY OF PROJECTS. FROM: Whitty and Maylor (2009)

Hertogh and Westerveld (2010, p. 197) define two types of project complexity: *detail complexity* and *dynamic complexity*. Detail complexity refers to the traditional view where complexity is created due to many interrelating components with a high degree of interrelation. Dynamic complexity refers to the modern view where complexity is created due to an evolving project over time and a limited understanding and predictability of the project.
They do not mention perceived complexities explicitly within their research but do make two interesting remarks: the first is that changing parties and stakeholders are a source for dynamic complexity, which could mean that different perceptions are a cause of dynamic complexity since every stakeholder has its own perception on complexity. The second is the indication of subjectivity in the project managers´ judgement on the uncertainties of the project: this judgement is a key decision within project management and could refer to a certain perceived complexity of the project manager.

Koppenjan*, et al.* (2011) underline the vision of Hertogh and Westerveld but refer to detail complexity with the term *structural complexity*. They characterise the dynamic complexity of a project as unpredictable, uncertain and emergent. The structural complexity can on the contrary be quantified, measured and prepared for. They also make no remarks of different perceived complexities.

Favari (2012) focuses his research on the construction of urban infrastructure and distinguishes two types of project complexity: the complexity of the project itself and the complexity of the environment. This environment becomes complex due to the interconnection of the urban city with infrastructural projects whereas these cities are increasingly more open and interconnected to the rest of the world: this means that anything coming from anywhere could influence the project at any time.
He does not mention any form of different perceived complexities.

Ireland *et al.* (2012) make a strong separation between simple, complicated and complex projects. Complicated and complex projects can be identified by determining the degree of freedom of system components relative to the number of control tools available within the system: if the level of freedom exceeds the number of control tools the system can be called complex. They label these projects as Systems of Systems projects (SoS) and distinct three types of SoSs: traditional SoSs, where an existing system is included in a project, SoSs which require systems thinking and systems which integrate independent assets into a larger system.

Davies and Mackenzie (2013) also identify systems of systems as the main unit of complexity. They distinct single systems, in which several sub-components have to be integrated, and systems of systems, which consist of multiple systems that have to be combined into one system (figure 2.2). An example is the difference between an aircraft and an airport: an aircraft is a system with several sub-components which must be integrated and controlled and an airport consists of multiple systems which all need to be combined in a system of systems (or *meta-system*).

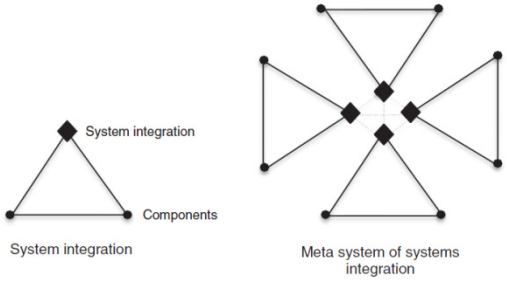


FIGURE 2.2 DIFFERENCE BETWEEN A SYSTEM AND A META-SYSTEM. FROM: Davies and Mackenzie (2013)

These reviews give altogether a more comprehensive definition of the two types of complexity that were explained earlier. This split in project-complexity-type is marked in this research as the difference between *complicated* and *complex*, where several definitions contribute to either the definition of complicated projects or to complex projects.
Table 2.1 shows the definitions of the different sources and their contribution to either the definition of complicated projects or the definition of complex projects.

TABLE 2.1 CATEGORISATION OF DIFFERENT DEFINITIONS OF PROJECT COMPLEXITY

Source	*Complicated*	*Complex*
Baccarini (1996)	Many different & interdependent parts	-
Williams (1999)	Structural uncertainty	Uncertainty
Thomas and Mengel (2008)	-	Chaotic, dissipative and adaptive systems
Whitty and Maylor (2009)	Independent structural complexity Independent dynamic complexity Interacting structural complexity	Interacting dynamic complexity
Hertogh and Westerveld (2010)	Detail complexity	Dynamic complexity
Koppenjan, et al. (2011)	Structural complexity	Dynamic complexity
Favari (2012)	Complexity of projects	Complexity of environment
Ireland, et al. (2012)	-	System of systems
Davies and Mackenzie (2013)	System	Meta-system

The different definitions of complex projects shown in table 2.3 and the acknowledged sources in the previous section leads to the following formulation of project complexity:

> **Project complexity is the degree of 'how complex a project is': a project can be categorised on an imaginary scale ranging from simple via complicated to truly complex projects. Truly complex projects are projects which are a system of systems and in which the different sub-systems are interconnected and influenced by each other. Project components act independent and the relation between these components results in unexpected and unforeseeable events. Therefore truly complex project cannot be controlled, determined or predicted: goals and boundaries are unclear and subject to continuous change.**

Complicated projects are projects with (many) interrelating components. Complex projects are complicated projects but also have an emergent character on top of their complicated character. This research will use the terminology of Hertogh and Westerveld (2010) (i.e. detailed and dynamic complexity) to refer to the two types of complexity which lead to either a complicated or a complex project.

The formulated definition already suggests some subjectivity in the assessment of project complexity since there is a 'scale' of complexity and not a strong single unambiguous definition. It is however still a general definition which covers all ranges of complexity as an umbrella and does not mention different perceived complexities explicitly although some sources (Thomas & Mengel, 2008; Hertogh & Westerveld, 2010) slightly indicate that subjectivity and perceptions might play a role in project complexity. The following will elaborate further on this topic but first the position of the author towards project complexity needs to be made clear: is project complexity good or bad?

> *"Make everything as simple as possible, but not simpler„*
>
> Albert Einstein, *scientist*

The quote of Albert Einstein emphasizes simplification as a solution for problems which automatically assumes that complexity is a negative concept. So is project complexity an inherently bad property within projects or is it a positive contributor to project quality? The author of this thesis believes in the latter statement of that question: project complexity leads to more valuable contributions to society in general and complexity must be 'played' with (Hertogh & Westerveld, 2010).
The objective that an LCP strives to achieve is not the LCP itself but a broader objective in which the LCP makes other developments possible that are beneficial for society (Giezen, 2012). This leads to the obligation of a project to take for example its environment into account and the public funding of projects obliges the project to justify the costs and to clarify the societal benefits of the projects. These factors all add up to the complexity of a project and sometimes make it a truly complex project, but they all serve for the benefit of society.
Reduction of complexity is however suggested by some authors as a way to deal with complexity and is for example reflected in the KISS-principle ('*Keep-It-Simple-Stupid'*) of Axelrod (1997) and within the quote of Albert Einstein formulated above.
The author of this thesis acknowledges that complexity reduction might work for some complex products but however not for LCPs: complexity reduction would lead to the loss of value within these projects due to their nature of enabling other developments.

So if the positive nature of project complexity within LCPs is accepted other ways besides simplification need to be found to deal with project complexity. A first step towards this management of project complexity is the operationalisation of the definition of project complexity: a break-down of the definition is necessary in order to make the assessment of project complexity within projects possible thereby making the definition workable for constructing practice. The following part will address four authors that contributed to the operationalisation of project complexity.

Hobday (1998) operationalises project complexity by introducing the term Complex Products and Systems (CoPS) as a product category. A LCP is an example of CoPS, where the term complex refers, among other things, to the number of customised components, the breadth of required knowledge and the degree of new knowledge involved: he developed a framework in order to assess technical complexity on a total of sixteen elements.

Maylor (2010) designed the MODeST framework in order to assess project complexity within projects. This model is based on five elements of complexity: Mission, Organisation, Delivery, Stakeholders and Team. These categories each contain five elements which contribute to project complexity. Together these 30 elements focus themselves on the *managerial* complexity of projects rather than technical complexity and therefore seem to be an addition to Hobday's CoPS framework.

Bosch-Rekveldt (2011) operationalises the term project complexity to a far extent by defining project complexity in the TOE-framework and thereby combines all ranges of complexity into one model. This framework consists of 57[1] specific elements, divided over Technical, Organisational and External buckets, which all together form the complexity footprint of a project. This framework can be seen as a combination of scientific theoretical knowledge and practical knowledge derived with interviews.
She furthermore indicates that the complexity footprint for each project needs to be assessed individually and that the framework can assist in constructing such a complexity footprint because it can add-up views of different involved parties and stakeholders: she thereby indicates that different perceived complexities exist. It underlines the dynamic character of project complexity since the complexity footprints needs to be re-assessed in the project due to the phenomenon of dynamic complexity.

[1] The original TOE-framework consisted of 50 elements, it was however adapted to the construction industry and was therefore expanded with 7 extra elements (Bosch-Rekveldt, 2013).

Vidal, *et al.* (2011) give a more broad definition of project complexity by formulating complexity as a certain part of a project which cannot be understood, foreseen or controlled, even though that there might be a rather complete set of information available. They however also indicate that the operationalisation of definitions of project complexity is poor since measurement tools of project complexity are inadequate. They designed the Analytical Hierarchy Process (a multi-criteria decision making method) in order to assess project complexity within projects: by scoring 70 elements contributing to project complexity the involved parties in a project can 'score' the overall project complexity within a project. This method also acknowledges different perceived complexities since it uses several respondents to score the complexity of a project.

These four models immediately show the role of perceived complexities within a project: every assessment of project elements contributing to project complexity is a subjective assessment and cannot be seen as a purely objective task. This makes the assessment of project complexity a subjective matter and different perceived complexities of different individuals appear in these assessments (Bosch-Rekveldt, 2013).
Take for example the element of 'number of involved external stakeholders' within projects: some practitioners might indicate that this element is the most contributing element to project complexity because these stakeholders can influence project performance significant while others do not perceive any complexity in this element because they have nothing to do with external stakeholders due to their role in the project.

It now also becomes clear how this research contributes to existing knowledge about project complexity: by understanding perceived complexities and its consequences this research contributes to the operationalisation of the theoretical definition of project complexity into construction practice. It creates knowledge on how project complexity within LCPs is assessed. This assessment will be done with the help of the TOE-framework which also seems to be the most comprehensive framework of the four mentioned frameworks above: it is, together with the framework of Vidal, the most elaborated framework of the four models. The other two models (Hobday and Maylor) only address technological or organisational complexity. Of the two elaborated models the TOE-framework is primarily designed for construction projects and it was therefore seen as the most suited framework to be used in the research.

2.2. Perceived complexities

The previous section gave a definition and interpretation of project complexity and showed that literature made a first step in operationalising this definition to be used in practice. In this 'bottom-up assessment' of project complexity the different perceived complexities of individuals play a role.

But how can these perceived complexities be described and understood? Literature on the science of cognitive psychology helps in this process. By regarding theories on perceptions it can be better understood how practitioners construct their perceived complexity.

The existence and sources of perceptions have been first researched by Brunswik (1952) who conducted research on the origins of *visual perceptions*. He argued that any organism has per definition an interface with its environment as any organism perceives its environment differently. He designed a model which describes this interface between an organism and its environment: this model is called the *Brunswikian lens model* and is shown in figure 2.3. The lens model of Brunswik was first used for the explanation of visual perceptions but was very soon used in order to explain the process of human judgement (Hammond & Stewart, 1975).

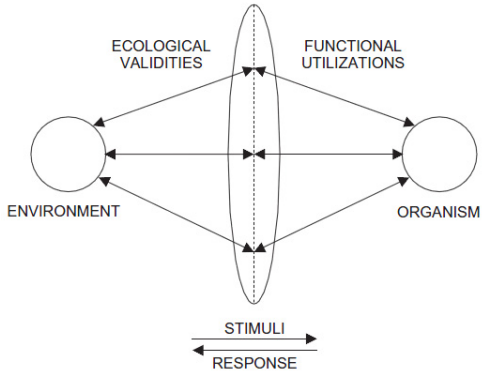


FIGURE 2.3 THE BRUNSWIKIAN LENS MODEL. FROM Figueredo *et al.* (2006)

The lens model describes the process of perception-building within an organism. It shows that an organism perceives the environment by the identification of *cues*: these are the ecological elements an organisms selects to build its perception upon. Since an organism is not capable of comprehending all cues from the environment it selects certain cues in order to come to a judgement on that environment (Hammond & Stewart, 2001).
This theory was expanded by Scherer (1978), arguing that a cue is not just noted but also valued in the form of a perceptual judgement, this is shown in figure 2.4. These perceptual judgements follow on each cue and then form the judgement of the environment.

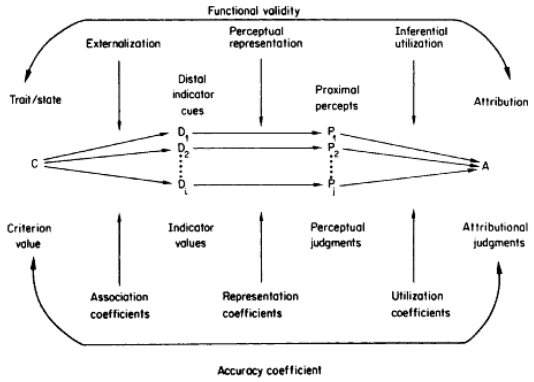


FIGURE 2.4 THE LENS MODEL OF SCHERER (1978)

Vicente (2003) designs another variation on the lens model, based on Stewart and Lusk (1994). They indicate that the cues are preceded by 'true descriptors' and then transformed by an organism into subjective cues. This model is shown in figure 2.5.

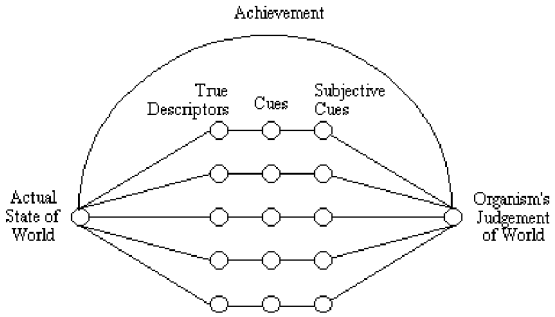


FIGURE 2.5 THE LENS MODEL OF STEWART AND LUSK (1994)

Since the research concentrates on the judgement of organisms (the respondents) about the ecology (the project complexity), the lens model seems appropriate as a starting point to construct a framework to describe the perceptions (H. Staats, personal communication, September 17, 2013).

The lens-models of Scherer and Stewart and Lusk were combined into a tailor-made framework used to describe different perceived complexities in this research. It is uses the concept of cues and subjective cues of Stewart and Lusk (1994) and the concept of perceptual judgements of Scherer (1978). This framework is shown in figure 2.6.

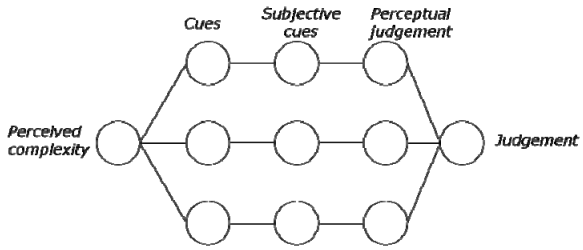


FIGURE 2.6 THE ADAPTED FRAMEWORK USED TO DESCRIBE PERCEIVED COMPLEXITIES

This framework will be used in chapter five in order to describe the different perceived complexities of practitioners.

2.3. Management of project complexity

The management of project complexity has gained increased attention in literature together with the increase of complexity in projects. This research identifies interventions dealing with project complexity and therefore needs a theoretical framework in order to better understand and categorise these different encountered interventions.

This paragraph considers multiple theoretical sources on complexity management and bundles them together in one overview which will be used to reflect on encountered interventions. Together with this assessment it is important to identify which type of project complexity the authors address with their project management approaches in order to understand if the approaches are meant to deal with complicated or with complex projects.

Before continuing it is important to define the term project management since it is the main topic of this section. Koppenjan, *et al.* (2011, p. 741) provide a comprehensive definition of project management which will be used throughout the rest of this thesis:

> **"Project management here represents the complete set of decisions regarding the set up, organisation and management of a project, taken during the various phases of the project, aimed at coordinating the efforts of the various actors involved in order to successfully realise the project„**

Baccarini (1996) mentions the tool of integration as the most important tool to deal with project complexity, achieved by communication, coordination and control. He does not further elaborate on this process of integration. Integration seems to be applicable to the management of detailed complexity within the context of his theory.

Williams (1999) indicates that traditional PM approaches do not seem to work on complex projects since they are unable to deal with feed-back loops, goal uncertainty and emerging problems during a project. He therefore argues to include more 'soft' techniques into project management without specifying these techniques. This split between traditional and soft approaches is believed to be the split between detailed and dynamic complexity.

Austin *et al.* (2002) address the complexity within the design activities of a project. They focus on the decomposition of this complexity and mention the Analytical Design Planning Technique as a tool in order to do so: this technique focuses itself on the design activities within a project which have an iterative nature and can therefore not be controlled with the help of more traditional PM tools, such as the critical path method.
This view reflects the view on project complexity as being detail complexity, proven with the used terms 'decomposition' and 'control'. This theory is therefore more suitable for complicated projects rather than complex projects.

The following three authors all emphasize the balance between two different management approaches and are therefore very similar to each other.

Thomas and Mengel (2008) describe how the education of project managers should be in order to deal with project complexity. Analysis of this description led to how Thomas and Mengel think complexity should be managed and several interventions were found. Some examples of these interventions: change should be supported, networks should be self-organizing and uncertainty should be coped with. This view reflects the dynamic nature of complexity and is therefore a contribution to the management of dynamic complexity.
They however also indicate that traditional management tools should be thought to more junior project managers to teach them the basics of project manager, which is in its turn a response to detailed complexity: both complexities are therefore treated by Mengel.

Hertogh and Westerveld (2010) see complexity as a phenomenon which can be played with and propose a combination of two different approaches as the ideal way to deal with project complexity. First *systems management* is indicated as a way to control detail complexity which is focussed on controlling the project. The second interaction is *interactive management* as a way to deal with dynamic complexity: interactive management focuses on the externalities of projects and on stakeholders' satisfaction. *Dynamic management* is the combined application of these two approaches, which can be characterised as the balance between control and interaction.

Koppenjan*, et al.* (2011) emphasize the necessity of balance within a project management approach: the balance between control and flexibility. Both need to be combined in effective project management and they are classified with the terms *predict-and-control* (with a strong focus on front-end analysis) and *prepare-and-commit* (with a strong focus on change).

Leijten (2012) focuses on the role of risks in the decision-making within complex projects. He argues for a decision-making strategy in which risks are perceived as a central point in decision making, not as a disadvantageous side effect. This approach grows awareness on risks and focuses efforts on the mitigation of risks within the chosen direction instead of a risk-trade-off which leads to inadequate decision making since the future cannot be predicted.

Favari (2012) stresses the fact that complex projects are impossible to plan and control and therefore suggests several key-interventions in managing complexity in urban infrastructural projects. These interventions are based on the 'project management second order' from Saynisch (2010) which is indicated with the short term 'PM-2'. The interventions are formulated below:

- The project sponsor needs to be made clear to all involved stakeholders in order to achieve a highly involved project sponsor that paves the way for Project Delivery Organisations.
- Organisational network mapping needs to be applied in order to identify all relevant stakeholders of the project.
- Communication management is an important aspect of the project and needs to be done by a professional part of the Project Delivery Organisation on both the strategic and tactical level.
- All risks need to be delegated to the contractor in order to guarantee involvement of the contractor during the entire life-cycle of the project.

It must be emphasized that these interventions are explicitly used to cope with complex *urban* infrastructure projects, but they do however outline a management approach towards project complexity and are therefore described in this section.

Bértholo (2013) mentions the shadow side of project management as the most important concept within project management and addresses the management of this shadow as key component within PM. The shadow refers to the negative side that every intervention has since every intervention consists of a positive and negative contribution to the project. This shadow origins in the split between body/mind and manifests itself within PM approaches mainly due to a control, planning and rational thought approach: this approach assumes a rational one-to-one relationship between situation, action and direction of the solution but it shows however little acknowledgement for people, teams and cultures and is incapable of dealing with disorder, chaos and unmanageability. A shadow can become the enemy of 'others' in the project resulting in an *us-vs.-them* mentality.
Addressing this shadow within project management results in a more mindful and organic way of project management, which is build on a holistic approach of project management.

The reference to chaos, uncertainty and unmanageability of projects furthermore indicates that this approach refers to the management of dynamic complexity.

Best, *et al.* (2013) also assessed different types of interventions (just like this research intends to do) in construction practice in order to link these interventions to organisational cultures within companies. This assessment led to three types of interventions which break apart into 13 sub-categories of interventions. The main types are controlling interventions, connecting interventions and actuating interventions. Their subcategories can be found in table 2.2.

TABLE 2.2 DIFFERENT INTERVENTION TYPES. FROM: Best, *et al.* (2013).

Controlling interventions	*Connecting interventions*	*Actuating interventions*
Re/establish structure	Connect people	Encourage ownership
Manage the stakeholders	Create a shared vision	Learn by sharing
Manage scope	Manage relationships	Encourage innovative thinking
Minimize discussions		Bring problems on the table
Manage expectations		Bring into action instead of thinking

Controlling interventions aim to gain control on the project, connecting interventions aim to connect people and thoughts and actuating interventions aim to move people towards an action or a direction. With these three types of interventions both the detailed and dynamic complexity of projects are addressed.

Davies and Mackenzie (2013) first emphasize that there is no magical intervention to deal with every complex project: they are all somewhat unique and therefore all need different approaches. They also rediscover the concept of systems integration due to a better understanding of projects as system of systems. At a systems level the project needs to be decomposed and the interfaces need to be managed, but at a meta-systems level there must be certain flexibility in order to cope with the uncertainty which cannot be eliminated within complex projects: the interaction between the different systems cannot be predicted once they are put together. They refer to this flexibility as 'disciplined flexibility' which indicates a balance between meeting schedules and adapting to changing and emergent situations. Part of this management is the ability to freeze and unfreeze systems when necessary. The combination of the two management approaches on systems-level and on meta-systems-level displays a management approach that focuses on both detailed and dynamic complexity.
Davies and Mackenzie strengthen the earlier formulated view that an effective project management approach is a combination of two types of management. They reflect these two approaches on the two types of projects formulated earlier: systems and meta-systems.

Locatelli *et al.* (2013) strongly connect project governance to systems engineering and argue that systems engineering can be used in order to achieve a holistic project governance structure within a project: it supports communication between multidisciplinary teams and guarantees project delivery with a focus on the benefit for the project in the entire life-cycle. Systems engineering can be seen as a very extensive tool in order to control a project and is therefore classified as a tool which is used to manage detail complexity.

The treated sources show a duality in possible management approaches, based on a control-approach or an hands-off-approach: the control-approach sees projects as systems that can be controlled, predicted and planned because they can be foreseen and forecasted. These approaches seem to connect to detail complexity.
The hands-off-approach suggests that projects cannot be forecasted and therefore not controlled. Situations might occur, and A might lead to B, but this is never certain in the hands-off- approach.
Four authors mention a combined application of the two approaches as the ideal way to deal with project complexity. This research labelled these approaches as combined approaches, since it combines the two approaches into one vision. The contributions of the different literature sources to these three categories can be found in table 2.3.

TABLE 2.3 CATEGORISATION OF DIFFERENT PROJECTMANAGEMENT-APPROACHES TO DEAL WITH PROJECT COMPLEXITY

Source	*Control-approach*	*Hands-off-approach*	*Combined-approach*
Baccarini (1996)	Integration	-	-
Williams (1999)	Traditional approach	Soft techniques	-
Austin, et al. (2002)	ADePDO	-	-
Hertogh and Westerveld (2010)	Systems management	Interactive management	Dynamic management
Thomas and Mengel (2008)	Traditional approach	Management based on understanding	Combination
Koppenjan, et al. (2011)	Predict-and-control	Prepare-and-commit	Combination
Leijten (2012)	-	Centralise risks in decision making	-
Favari (2012)	Plan and control	PM-2	-
Bértholo (2013)	-	The shadow of projects	-
Best, et al. (2013)	Controlling	Connecting Actuating	-
Davies and Mackenzie (2013)	Integration	Flexibility	Disciplined flexibility
Locatelli, et al. (2013)	Systems engineering	-	-

This overview led to the construction of a framework which is used to classify the encountered interventions further on in this research: it addresses the two different approaches (control and hands-off) and its characteristics in table 2.4. The combination of these two approaches leads to the most effective project management strategy to deal with project complexity according to literature.

TABLE 2.4 TWO IDENTIFIED APPROACHES TO DEAL WITH PROJECT COMPLEXITY

Characteristic	*Control-approach*	*Hands-off-approach*
Complexity type	Detail complexity	Dynamic complexity
Based on	Deterministic view on projects	Probabilistic view on projects
Focussed on	Control	Change
Units of focus	Components of a project (details)	Entire project (holistic)
Intervention types	Controlling & Actuating	Connecting & Actuating

This framework displays an elaborated overview of the possible management approaches to deal with project complexity and there are three complementing remarks on project management approaches that are worth knowing.

The first is from ecologist Berlow (2010). He supports the idea of embracing complexity and even argues that the embracing of complexity in a system can bring forward the simplest solutions, since a comprehensive understanding of a system pinpoints the few elements which are the most decisive for the system. This view seems to be applicable to detailed complex systems.
The second remark comes from Whitty and Maylor (2009) who indicate that there is a lack of known interventions to deal with truly complex projects but they also emphasize the fact that interventions do not necessarily have to be complex, as long as they work. They mention for example the Critical Path Method: this tool does not necessarily manage truly complex projects (since it is incapable to deal with uncertainties) but can be effective to a great extent within project management.
The third remark comes from Giezen (2012). He conducted research on the reduction of complexity as project management approach to deal with the complexity. He argues that this reduction is indeed a way to deliver a project on time and within budget but questions the reduced value of projects: decreasing complexity leads to a decreased project value since the project cannot function as leverage for other spatial developments but becomes a goal in itself.

Finally, several authors (for example Von Glinow and Mohrman (1990); Cicmil*, et al.* (2006); Reyes (2012); Ahern *et al.* (2013)) emphasize the importance of knowledge management and learning in complex projects: dynamic complexity makes it impossible to know everything at the start of a project and to predict, which makes the learning capability the most important skill to deal with project management. Ahern*, et al.* (2013) even argues that PM must make a shift from systems complexity to knowledge complexity.
These theories were initially not taken into account during the empirical research but they will be mentioned further on in this thesis when chapter seven will reflect on the found results.

2.4. Conclusion

Project complexity has been described in literature as either the interrelation between many components (systems-view) or as the uncertainty and emergent character of events (edge-of-chaos-view). Both views led to a combined and general definition of truly complex projects that is very broad and covers a wide range of complexity within projects. This definition makes a distinction between complicated and complex projects but is unable in drawing a hard line between them: they are elements of the same scale.

Recent literature operationalised this definition by assessing complexity within individual projects. This research contributes to that field of knowledge: by assessing the project complexity within LCPs with the help of the TOE-framework the different perceived complexities come to light and the understanding of these perceived complexities contributes therefore to the opertionalisation of the theoretical knowledge on project complexity.

The introduction already explained that the possible implications of perceived complexities on project performance are assessed by linking these perceived complexities to the interventions of individuals: this chapter adds the view that the type of project complexity determines the project management approach (for example Hertogh and Westerveld (2010); Koppenjan*, et al.* (2011)) but also that the project management approach influences the project complexity (for example Giezen (2012)). This is shown in figure 2.7.

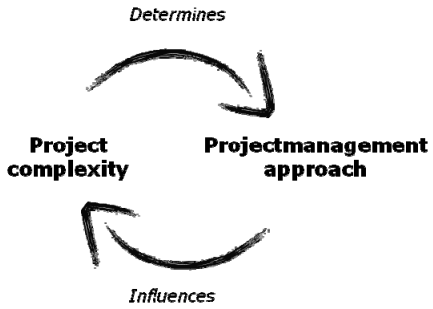


FIGURE 2.7 CONCEPTUAL FRAMEWORK ABOUT THE RELATIONSHIP BETWEEN PROJECT COMPLEXITY AND PROJECTMANAGEMENT APPROACHES

These relations create the proposition that a certain perceived complexity A leads to a certain project management approach B. This functions as a proposition within the rest of this research and will be further elaborated in chapter three.

This chapter also showed that project management approaches dealing with project complexity can be categorised as a control-approach, hands-off-approach or combined-approach. The research of Best*, et al.* (2013) was very similar to this research (since they also assessed interventions dealing with complexity in construction practice) and therefore their framework of controlling, connecting and actuating interventions was used in the identification and categorisation of interventions.

The framework constructed in this chapter to describe perceived complexities will be used and evaluated in chapter six.

3. Methodology

The introduction determined project complexity as a central component within modern project management of LCPs and that little is known about the recently uncovered perceived complexities. In order to conduct research on these perceived complexities a decent research design had to be made, which is presented in this chapter.

This chapter will unfold the research plan which was used in order to build the knowledge necessary to meet the objectives of this research as formulated in the introduction. It will start by explaining the general characteristics which are the result of choices that have been made (§3.1). These characteristics lead to a research strategy and the designed mechanisms to ensure its quality, which is the second part of this chapter (§3.2). The research process displays the major steps in this research and their corresponding results (§3.4). The chapter ends with the research propositions, thereby indicating the relation between the major topics of this research (§3.5).

3.1. General characteristics

The introduction already explained that this research continued on the research of Bosch-Rekveldt (2013): different perceived complexities were made clear and this research aims to understand these perceived complexities.

This research contributes to the knowledge field of management sciences: *project complexity* and its *management* are topics within management sciences.
Perceptions relate to the knowledge field of cognitive psychology and this research will therefore use some knowledge of this knowledge field but will however primarily focus on the knowledge field of management science.

It is the aim of the research to contribute to both theory and practice with this research. Theory on perceived complexities and its implications for project management within LCPs is limited. The introduction also showed that literature is increasingly focussed on the operationalisation of project complexity and interventions dealing with complexity.
Practice has become increasingly interested in the phenomenon of project complexity: the request of KING/RPA for further knowledge on this phenomenon is the prove of that increased interests.

The research was conducted with an inductive approach. This approach was chosen because the phenomenon of perceived complexities and its implications are little understood: it is therefore difficult to formulate hypotheses or strong propositions with the information available on these topics at the moment, making inductive research the appropriate approach towards the research.
Because no strong hypothesis could be formulated on the research topics, qualitative research opposed to quantitative research was chosen: this type of research is used to understand phenomena and discover the 'why' behind these phenomena (Marshall & Rossman, 2006), making qualitative research the appropriate form to achieve the objectives of this research.

3.2. Research strategy & quality

A case study was selected as design for this research and suits the needs for this research: project complexity is inextricably connected with the context a project is located in (Bosch-Rekveldt *et al.*, 2011) and a case research can conduct research on a phenomenon without extracting it from its context (Yin, 2003). In an embedded multi-case design five projects were selected which contributed 30 respondents to the research.

Data was primarily built with two types of data-collecting: a survey and in-depth interviews. The survey was based on the TOE-framework and asked respondents to score the TOE-elements on their contribution to project complexity[2]. The in-depth interview was used to understand the answers given in the survey. Chapter four will elaborate on the survey, in-depth interview and their relation.

Yin (2003) indicates that a research strategy within a case study can be of a descriptive, an explanatory and/or an exploratory nature. This research has all three characteristics:

- The *descriptive* nature is seen in the description of the perceived complexities of the respondents and a list of encountered interventions dealing with complexity.
- The *explanatory* nature is seen in the explanations for the different perceived complexities: by explaining the origins of perceived complexities they can be better understood.
- The *exploratory* nature is seen in the exploration that was done on the implications of different perceived complexities on projects' performance.

Verification and validation are important factors in designing a research and performing a research of good quality and Yin (2003) stresses the importance for internal and external validation of the research. The application of both within this research will be elaborated below.

Verification was done by verifying the produced data with their original sources: all the minutes of the interviews were verified with the respondents in order to verify if they were properly constructed. A case report was produced for each case which was then again verified with the project managers of these cases in order to verify if no biased information had entered the case study.

Internal validation was done with the help of several techniques. Triangulation, explanation building and sensitising concepts were used as tools to strengthen internal validation. All three will be explained below.
Triangulation refers to the process where at least three sources contribute to an outcome (Guion *et al.*, 2011). In this research triangulation was obtained by funding outcomes on at least three different respondents and preferably a combination of sources (interviews and survey results).
Explanation building is a way of data analyses that allows the researcher to extract internal valid information of the available data set (Yin, 2003). This process will be explained in detail in chapter four.
Sensitising concepts refer to the way a researcher regards the data-set (Blumer, 1954). It is used to formulate a direction of research and formulate propositions which are used further on in the research. This technique was especially applicable for the research on the implications of perceived complexities.
Internal validation was furthermore applied by discussing the intermediate results of the research with four project managers who also participated in the research. This validation confirmed the direction of the research and provided useful insights to proceed with the research.

External validation was done with two techniques: expert meetings and literature validation.
The expert meeting consisted of a KING/RPA event where approximately 30 construction practitioners participated in a group-discussion on the topic of this thesis. This discussion was initiated with a short presentation about the results of this research.
Literature validation is the process of reflecting the found results on literature in order to discuss the results and/or validate the found conclusions of the research.

[2] The construction of the survey was not part of this research: it was obtained from the research of Bosch-Rekveldt (2013)

3.3. Research process

The research process was based on the framework for research formulated by Oost and Markenhof (2002). This framework was used in order to create a tailor-made design for the research conducted. This design is displayed in figure 3.1.



FIGURE 3.1 DIFFERENT PHASES OF THE RESEARCH. ADAPTED FROM Oost and Markenhof (2002)

Every research phase of Oost and Markenhof (2002) was processed within this research. Table 3.1 shows the research phase formulated by Oost and Markenhof (2002), the way this phase was applied within the research and the section in which it was processed.

TABLE 3.1 APPLICATION OF THE RESEARCH PHASES OF Oost and Markenhof (2002)

Research phase	*Application within this research*	*Processed in*
Start	The prior research of Bosch-Rekveldt (2013)	Chapter 1
Question	Research question	Chapter 1
Strategy	Embedded multi-case study design	Chapter 3
Collect data	Survey & interviews	Chapter 4
Material building	Interview minutes and case reports	Chapter 5
Adapting data	Codification of interviews and descriptions of perceived complexities	Chapter 5 & Appendix B
Data analysis	Explanation building & descriptive research	Chapter 6
Interpreter data	Hypothesis formulation & validation	Chapters 6 & 7
Answer	Conclusions	Chapter 8

3.4. Research propositions

Every research needs a hypothesis or at least a proposition to give direction to the research (Yin, 2003). The introduction and chapter two already indicated propositions and this section will explicitly sum-up all propositions that were used to aim the research: because of the exploratory and explanatory nature of this research it must be emphasized that the statements formulated below are propositions and *not* hypotheses. They are only used to guide the research and not intended to be rejected or confirmed.

1. Perceived complexities originate in the role, education and/or interests of practitioners.
This research aims to understand perceived complexities and its origins. The number of possible sources for perceived complexity is however gigantic and too much for this research. It was therefore decided to focus the research on the role, education and interests of practitioners: these three sources were chosen based on the tacit knowledge of the supervisors and the researcher.
The research did however not exclude other sources as possible sources if they popped up during the in-depth interviews: it just did not look explicitly for other sources besides the mentioned three.

2. Perceived complexities influence interventions dealing with complexity.
This proposition was derived from literature in chapter two where it was concluded that project complexity influences project management. It was also concluded that project complexity was subjective and that project management consisted of interventions dealing with project complexity. The proposition is that these interventions are therefore influenced by perceived complexities.

3. Interventions dealing with project complexity influence performance of projects
Interventions aim to influence the performance of projects by definition, regardless of the result of the intervention.

4. Perceived complexities influence project performance
This research aims to understand the implications of different perceived complexities on project performance: perceived complexities influence interventions (proposition two) and interventions influence project performance (proposition three) therefore perceived complexities influence project performance.

The introduction already described the four objectives of this research and the propositions make the interrelation between these four objectives clear. The research objectives are described below and it is indicated which proposition influences which objective.

- Perceived complexities (proposition 1)
- Interventions dealing with complexity (propositions 2 and 3)
- Implications of perceived complexities (proposition 4)
- Implications for project management

The research objectives and their interrelations are also graphically visualised in figure 3.2.



FIGURE 3.2 INTERRELATION OF THE RESEARCH'S OBJECTIVES AND PROPOSITIONS

The blocks used in figure 3.3 are referred to as *content blocks* and they are used to break down the contents of the research in four clear sub-parts.

4. Research design: case study set-up

Chapter three introduced the case study as the appropriate research form to answer the formulated research questions. This chapter presents the detailed set-up of this case study.

By presenting the case study design (§4.1), the case protocol (§4.2), the selection of the cases (§4.3) and the performed data analyses (§4.4) this chapter explains *how* the case studies were conducted. Chapter five will present the results of this process.

4.1. Case design

The research was conducted as an embedded multiple-case study: this design consisted of multiple cases contributing to the data set with sub-elements embedded in each case (Yin, 2003). The presented research blocks can be seen as the embedded elements in this case study, which leads to the following embedded elements:

- Sources of perceived complexities
- The influence of perceived complexities on interventions
- The impact of different perceived complexities on project performance
- The impact of different perceived complexities on project management

Yin (2003) indicates that the research design must be a logical route for 'getting from here to there'. He mentions five important components in a case design:

1. A study's question
2. Its propositions
3. Its unit(s) of analysis
4. The logic linking the data to the propositions
5. The criteria for interpreting the findings

The application of all five components of Yin (2003) is elaborated below.

The *study's question* and its sub-questions were formulated in the introduction of this thesis.
The *propositions* of the research were formulated in chapter 3.4.
The *units of analysis* consisted primarily of construction projects in The Netherlands. The actors involved in these construction projects were the subordinated units of these projects. Every case consisted of one construction project with five, six or seven respondents functioning as subordinated units. It is desirable that the different cases can be compared with each other and it is therefore desirable to group the different respondent in identical categories. It was chosen to categorise the respondents based on their roles. The framework to do this was based on Hertogh and Westerveld (2010), they identified the civil principal, the project delivery organization, the constructor, non-governmental organisations (*NGOs*) and local stakeholders.

The following groups of actors were identified based on this idea:

- *The civil principal*. This group consisted of all respondents which acted on behalf of one of the public bodies that functioned as client. This includes all respondents working at funding agencies and respondents working in the same organisation as the Project Delivery Organisation but from a principals' perspective. Advisors to the civil principal were also categorised as civil principal.
- *The Project Delivery Organisation*. This group consisted of all respondents that were a member of the Project Delivery Organisation responsible for the execution of the project. They are often employed in the same organisations as the civil principals. Advisors to the Project Delivery Organisation were also categorised as Project Delivery Organisation.

- *Local stakeholders*. This group consisted of all respondents that were an involved local stakeholder. NGOs, such as organised neighbourhood initiatives, were also considered as local stakeholders.
- *The contractor*. This group consisted of all respondents that worked for the involved contractor.

The mentioned actors and their interrelations are graphically displayed in figure 4.1.

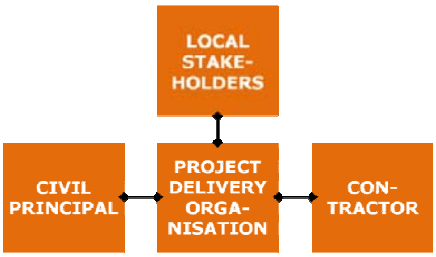


FIGURE 4.1 OVERVIEW OF THE DIFFERENT ROLE-GROUPS IDENTIFIED IN THIS RESEARCH

The *logic linking the data to the propositions* was created by performing data-analyses. By applying explanation building and descriptive research these data-analyses were performed: their application will be explained in detail in chapter 4.4.
The *criteria to interpret the results* were obtained by internal and external validation as described in the previous chapter and performed in chapter seven.

The case study started with a survey on project complexity. This survey was based on the TOE-framework and asked the respondents to rank 57 pre-defined elements that might contribute to project complexity on their actual contribution to project complexity. Respondents could score an element from 0 to 4, where a 0 meant 'not contributing to project complexity' and a 4 'contributing in a high degree to project complexity'. A list of these elements can be found in appendix C. It also asked respondents to rank the technical, organisational and external elements as groups relatively to each other.

After the survey the in-depth interviews were conducted (the interview questions can be found in appendix A). The interview consisted of three parts, was semi-structured and consisted of open questions.
First, all respondents were asked about their role, educational background, work experience and interests in the project. This information was used to understand the person behind the perception and to verify the connection of these aspects to the actual perception.
Second, all respondents were asked on their top-3 TOE-elements contributing to complexity (these top-3 lists were derived from the survey). The objective of this phase was to clarify these top-3 examples in order to understand the perceptions of the respondents. Respondents were therefore explicitly asked to provide examples and make their top-3 lists explicit.
Third, all respondents were confronted with the top-3 of their project manager in order to grasp their opinions on different perceived complexities.

The research strived for anonymity by naming the respondents as anonymous as possible in order to obtain as much 'uncoloured' information as possible. The respondents will therefore remain anonymous within this research and the cases will not be mentioned by name or geographical position.

4.2. Case protocol

The validity of the case research was enhanced by following a specified case protocol. This protocol made sure that the researcher followed the same procedure for each interview thereby preventing respondents from coming biased by the researcher.

All respondents were notified of the research with the same e-mail prior to the interviews. This message explained in short the goal of the research and the time needed to conduct the in-depth interviews. Most respondents already filled in the survey approximately nine months before the interview (round 1); those who did not were asked to fill in the survey at that moment (round 2). The survey was in both rounds exactly the same.
The interviewer did not study extra materials about the projects prior to the interviews: this ensured an unbiased interviewer and at the same time created the opportunity to study the influence of different perceived complexities: by using the different perceptions of the

respondents to construct an image of the project, the interviewer experienced the effects of different perceived complexities on that image in first person.

First, all five project managers were interviewed thereby verifying their personal top-3 lists. All other respondents were then confronted with the actualised top-3 elements of their project manager in order to evoke their reaction on the differences. Respondents were only confronted with the top-3 elements that were confirmed as valid by the project managers.

Prior to each interview, the respondents (30 in total) received the same introduction of the interviewer, the research and the interview itself (this introduction can also be found in appendix A). The interview consisted of 17 open questions for project managers and 18 open questions for all other respondents. Some questions were categorised as must-haves: these questions were always asked on all respondents. Other questions were categorised as nice-to-haves: these questions were only asked if the respondents and the time provided the necessary room to ask these questions. Interviews took approximately 60-90 minutes.

During the interview all respondents were confronted with the three elements that they pointed out as top-3 contributors to project complexity in the survey. If the survey was answered during the first round, the respondents were asked if the chosen elements were still applicable to the current situation. The interview tended to focus itself on all the elements that were still applicable, but also left room to look in retro perspective to the elements that became less applicable and how this occurred.

During the interviews all respondents were encouraged to illustrate their answers with striking examples, making the perceived complexities better to understand. The comments of the respondents on their top-3 elements (open field in the survey) were also read out loud to the respondent in order to help the respondents memorize their given answers.
At the end all respondents had the possibility to say whatever they still had to say on whatever topic they thought would contribute to the research.

All interviews were taped with the permission of the respondents and elaborated into interview minutes. These minutes were checked with all respondents in order to verify if the elaboration had been done correct.
These minutes served as input for the project reports. These project reports summarized the given answers for all respondents within the project: it thereby provided tailor-made feedback for each project. These project reports were also validated with the project manager of the specific project to check if no biased information (e.g. strategic remarks) entered the research.

4.3. Case selection

Five construction projects were selected to function as cases in the case study. All five cases were selected from the KING/RPA network. The KING/RPA network consists of multiple construction projects which are affiliated to the network in order to exchange knowledge and experiences between each other.
This indicates that all projects in the KING/RPA network have a desire to learn from each other and share knowledge which leads to a high expected degree of cooperation with the research.
The participants for each project were selected by the project manager and can all be classified as construction professionals. This self-selection ensured cooperation and is furthermore in line with the view that this research is of explorative nature: since no hypothesis is formulated whatsoever there is no desire to conduct research on a specific type of respondent within each project. It was however the aim to account for all four types of actors within each case as presented earlier (civil principal, Project Delivery Organisation, contractor and NGOs). Unfortunately none of the cases managed to account for all four groups of actors.

The cases were selected based on the wide variety in typology, thereby enhancing the representativeness of the five cases for the Dutch construction industry. All cases were in the preparation or construction phase during the research which increased validity: this made sure that respondents were ‘living’ and experiencing the complexity during the interviews and did not had to rely on their memories.

All projects involved the construction of a civil structure (wet or dry) or a utility construction. There were one or more public bodies represented in every project and there was always a public client. With CAPEX in a range from €35 million to €500 million or more [3] and several stakeholders involved, all projects could be called 'complex' if the rough outlines were to be regarded. One project was still in the preparation phase, meaning that it was not been put on the market to find a contractor. One was in the design phase (a contractor was awarded with the D&C contract and was designing the project) and three were in the construction phase, where two of them were expected to be completed within a year from the research. For one project however, the scope was changed during construction phase which led to preparations that could result in an extension of the construction phase.

The cases were initially selected on the wide variety in the perceived complexities of the respondents in the first round of surveying. This variety might however been reduced during the research since new respondents were added to the cases that did not participate in round one of the survey.

Table 4.1 gives an overview of the five projects selected for the case study.

TABLE 4.1 OVERVIEW OF THE SELECTED PROJECTS AND THEIR CORRESPONDING PHASES

#	*Project*	*Phase*
1	New metro and bus station in urban area	Preparation phase
2	New ship lock in rural area	Design phase
3	New museum in rural area	Construction phase
4	New metro station in urban area	Construction phase
5	Expansion of a train station / development of the near area around the train station	Construction phase / preparation phase

4.4. Data analysis

Explanation building and descriptive research were performed in order to analyse the available data which consisted of the minutes of the interviews. These minutes were all checked with the respondents in order to verify them.

The explanation building resulted in the formulation of hypotheses which were used to answer the research questions on sources of perceived complexities and on the impact of different perceived complexities on project performance.

The interviews were conducted in Dutch. In order to prevent falsification of the data due to translation, the different paragraphs of the interviews that were used for data analyses were not translated. This translation was only done on the interpretations of the researcher on these paragraphs, which decreased the chance of falsification due to translation.

4.4.1. *Descriptive research*

Descriptive research is used in order to make large amounts of data manageable and thereby provide an opportunity for further analyses (Yin, 2003): by describing the phenomena that were encountered more insights were created. Descriptive research was used to create 'secondary data sources'.
The descriptive research led to three secondary data sources (figure 4.2): descriptions of perceived complexities, case reports and an overview of encountered interventions dealing with project complexity. The descriptions of perceived complexities (appendix B) and the case reports (chapter five) were also used in the process of explanation building. The list of management interventions will be presented in chapter six.
The relation between the secondary sources is justified with the summary-aided approach from Miles and Huberman (1994). This model indicates a strategy to perform data-analysis and was used to design the descriptive research.

[3] Respondents of the most expensive project do not agree on this sum, but it is clear that €500 million is the minimum cost of this project. This exact amount is therefore unclear.

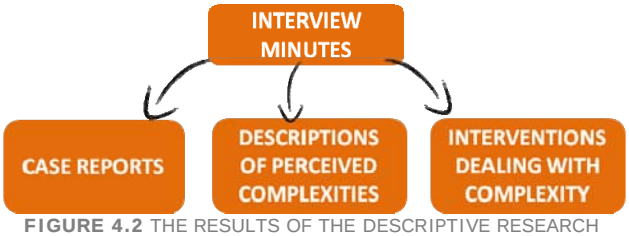


FIGURE 4.2 THE RESULTS OF THE DESCRIPTIVE RESEARCH

The details of all three secondary types of data-sources will be described in the following.

1. Descriptions of perceived complexities
All perceived complexities were first described and reflected upon. This was done based on the interview minutes and with the help of the derivative Brunswik lens model which was constructed in chapter two and shown again in figure 4.3.

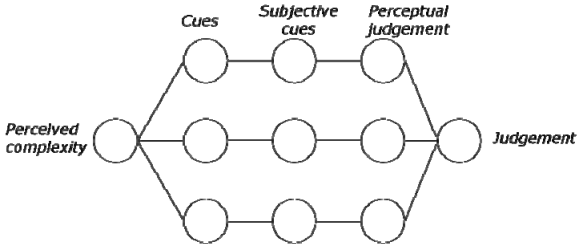


FIGURE 4.3 THE LENS MODEL USED TO DESCRIBE PERCEIVED COMPLEXITIES

The cues in this framework are the top-3 lists of TOE-elements: the TOE-elements function as independent variable because they are determined and suggested by the researcher. All other positions in the framework (perceived complexity, subjective cues, perceptual judgements and final judgements) were derived from the selected cues and the explanation provided by the respondents in the in-depth interviews. Perceived complexities are thereby correctly described with a method based on existing knowledge (H. Staats, personal communication, September 17, 2013).
Cues were transformed into subjective cues: these subjective cues were derived from the answer of the respondent and answer the question 'what the respondent really meant by selecting that element'. A perceptual judgement on that subjective cue was often given by the respondent. The sum of all perceptual judgements forms the complete perceived complexity of a respondent.
The subjective cue and perceptual judgement were left blank if there was no information available on the subjective cue or the perceptual judgement.

A reflection on the perceived complexity was performed once it was described with the help of the framework. This reflection focussed on the lens model and the connection between the perceived complexity and the role, education and interests of the respondent.
Besides a reflection on the perception, a reflection on the differences between the project manager and the respondent was also described.

2. Case reports
After constructing the descriptions of the perceived complexities all interviews were summarized in case reports which can be found in chapter five. These reports give an overview of the results of the interviews and the survey and consist of three independent parts.
The first part of the report displays a description of the project and a judgement of the researcher on the performance of the project.
The second part focuses itself on the different perceived complexities and start with an overview of the survey results: these results were the starting point for the in-depth interviews which were summarized below the survey results.
The third part concentrates on the reactions that respondents gave on differences in perceived complexities. It starts with an overview of the differences between the respondents and the project manager and then summarizes the reactions of respondents.

Two types of indicators were designed that gave more insight in the perceived complexities and its differences: the complexity score and the unanimity score. Both will be explained below.

The complexity score gives an indication of the degree of complexity that the respondent experiences. This score can then be used relatively to other respondents within the same case to give an indication of how complex the respondent experiences the project. The score was derived with the formula shown in formula 4.1:

$$Complexity\ score = \frac{\text{sum of the scores on the different elements}}{\text{maximum score possible}}$$

FORMULA 4.1 COMPLEXITY SCORE

The unanimity score gives an indication of the degree of unanimity within the case. It counts the differences between answers of respondents and divides this difference by the maximal possible difference: this gives an indication of how different the answers are between respondents (formula 4.2).
Take for example a case with four respondents. For each element (57 in total) the differences between the scores have to be counted and divided by the maximum difference possible. This percentage has to be extracted from 1 in order to get the unanimity score. This is shown in the formula below where *A* is the score of respondent 1 on the element, *B* the score of respondent 2 on the element, *C* the score of respondent 3 on the element and *D* the score of respondent 4 on the element.

$$Unanimity\ score = 1 - \frac{\sum_{\text{element } 57}^{\text{element } 1}(|A-B|) + (|A-C|) + (|A-D|) + (|B-C|) + (|B-D|) + (|C-D|)}{(\text{maximum difference possible in element}) * 57}$$

FORMULA 4.2 UNANIMITY SCORE

3. List of interventions dealing with complexity
The research focussed on multiple groups of interventions because complexity is managed on two levels: on a case level and on a personal level. On a case level the complexity is managed in general terms, on a personal level the complexity is managed for each respondent individually. The research also focused on a third group of interventions: specific interventions used in order to manage the different perceptions on complexity.

All three groups were extracted from the interviews with the help of field coding. After coding the interviews, the researcher summarized and interpreted the different interventions that were coded. By doing so, the data became comparable making it easier to categorise the different interventions in literature.

These three data sources, derived from the interviews, were used to conduct the rest of the research. Each data source corresponds with a content block as described in chapter three. Table 4.2 gives an overview of the data sources, where they can be found in this thesis and the content block that they contribute to.

TABLE 4.2 DATA SOURCES AND THE CONTENT BLOCKS THAT THEY SERVE

Data source	*Results*	*CB 1*	*CB 2*	*CB 3*	*CB 4*
Interview minutes	-	✓	✓	✓	✓
Descriptions of perceived complexities	Appendix B	✓			
Case reports	Chapter five	✓	✓	✓	
List of interventions dealing with complexity	Chapter six		✓		✓

4.4.2. *Explanation building*
After the production of the secondary data-sources the process of explanation building started. Explanation building is a certain type of pattern matching and is used to explain the 'why' behind certain phenomena (Yin, 2003).
Explanation building starts with an initial hypothesis which is a certain explanation for a phenomenon. This initial hypothesis is then tested within each individual data-source (i.e. the interview minutes) to see if the hypothesis is valid for that search. If so, the hypothesis is tested in the next source. If not, the hypothesis is altered in such a way that it fits the data source.

The formulation of the initial hypothesis was also done based on an altered model of Miles and Huberman (1994): three sources led to the formulation of initial hypotheses that were used in the explanation building process. This approach is shown in figure 4.4.

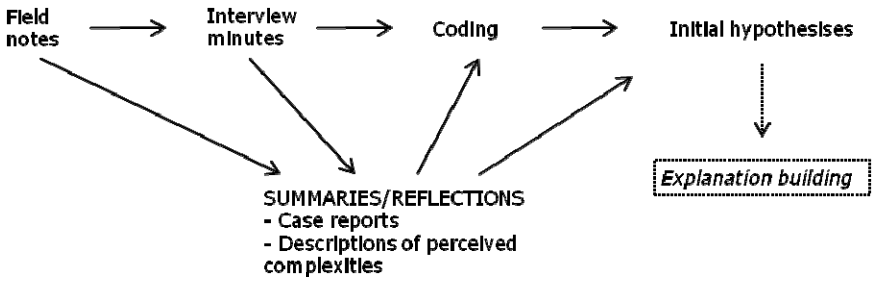


FIGURE 4.4 ALTERED SUMMARY-AIDED APPROACH (Miles & Huberman, 1994) USED FOR EXPLANATION BUILDING

5. Results of the case studies

The perceived complexities of construction practitioners differ from one to another. It is argued in the introduction that it is desirable to know why these differences occur, what their consequences are and how construction professionals deal with complexity in practice. Little is known about these two subjects, left alone the implications of differences in perceived complexities on the construction project.

Chapter four described the case study set-up and this chapter will provide the results of the case studies in the form of the project reports. It will give insights into perceived complexities and its implications by answering the following sub-questions:

- How can perceived complexities be described? *(sub-question A)*
- How can perceived complexities of construction practitioners be categorised? *(sub-question C)*
- What is the link between perceived complexities and interventions dealing with project complexity? *(sub-question D)*
- What are the implications of different perceived complexities on project performance? *(sub-question F)*

All five cases (§5.1 to §5.5) begin with a case description and a judgement of the researcher on the case performance. Then all perceived complexities of the respondents are described for each case followed by a description of the opinion of the respondents about differences in perceived complexities and their consequences. Each case is concluded at the end of each report. The conclusion of this chapter will answer the formulated research questions (§5.6).

5.1. Case report 1: new metro and bus station in urban area

This case covered the construction of a new bus station which would also partly function as a metro station. The bus station was build at the end of a metro line, so it would become an important transfer for passengers leaving and entering the metro.
The metro was built on an elevated level two floors up from ground level. The construction of the bus station would focus on the first level en the ground level thereby providing the transfer between bus and metro. Once finished the bus station would have an important regional function in public transportation.

The ground level consisted of multiple bus platforms, allowing passengers to enter and leave the bus. A large bicycle storage provided passengers the opportunity to park their bicycle at a safe place. The first level provided necessary services to passengers, such as shops, food and other leisure functions. The second level housed the platforms to enter and leave the metro. The total costs of the project were estimated by the respondents at €35 million.

The project performance was judged as poor by the author of this thesis. Ten years before the start of the research the first plans were already designed by a renowned architecture firm. The project had however not been finished during the research, nor had it really started: the project was still in the preparation phase and the tender had to be brought to the market in order to find a contractor.
Because the metro line had to land on the second floor of the bus station and the construction was delayed severely, the decision was made to disconnect the construction of the carcass and the rest of the contract in order not to hinder the construction of the metro line. The carcass was therefore already built during the research. The completion of the

station (including the facilities necessary to operate the metro) was however still in the preparation phase.

Approximately one year before the research the project was put on hold since there were too many uncertainties in the project. During the research the project was still on hold.

Many actors were identified in the project. First there was the Project Delivery Organisation which was assembled by one of the municipal departments. The term Project Delivery Organisation is however somewhat strongly stated since there was no fixed PDO. Besides this PDO there was also another PDO responsible for the construction of the metro line. Important interfaces between the two projects were the ICT facilities and the carcass, which hence had been constructed.
The same municipal organisation delivering the Project Delivery Organisation also functioned as civil principal. This agency was therefore both responsible for translating the political ambition into an assignment and translating this assignment into a tender. A funding agency was involved as sponsor of the project (so the financing did not came from the municipality itself).

The project manager suggested six respondents for this case; an overview of the different respondents is given in figure 5.1 and in table 5.1.

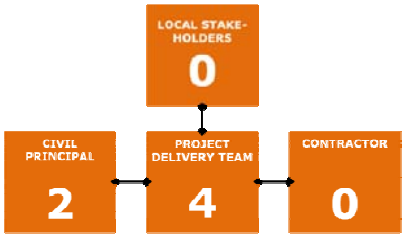


FIGURE 5.1 DISTRUBTION OF THE RESPONDENTS FROM CASE 1 ON ROLE-GROUPS

TABLE 5.1 OVERVIEW OF THE RESPONDENTS CASE 1

#	*Role*	*Stakeholder Group*
1	Project manager	Project Delivery Organisation
2	Civil client (municipality)	Civil principal
3	Interface manager of metro line	Project Delivery Organisation (advisor)
4	Former project leader engineering company*	Project Delivery Organisation
5	Project leader funding agency (project sponsor)	Civil principal
6	Former construction manager and technical manager*	Project Delivery Organisation

** These respondents were not active on the project anymore during the interviews. It was decided that their perceived complexity was still valid, because both had been active on the project for a long time and were only recently removed from the project.*

5.1.1. *Perceived complexities and interventions dealing with that complexity*

The respondents within this case were very much aligned when it came to the perceived complexities. Almost all perceptions focused themselves on the same problems within the project and all respondents explained how these problems affected their part of the project. The results of the survey can be found in table 5.2.

TABLE 5.2 OVERVIEW OF SURVEY-RESULTS OF CASE 1. THE NUMBER OF THE RESPONDENT IS INDICATED FOLLOWED BY THE RANKING OF THE TECHNICAL, ORGANIZATIONAL AND EXTERNAL ELEMENTS RELATIVELY TO EACH OTHER. THE TOP-3 TOE-ELEMENTS ARE THEN SHOWED FOLLOWED BY THE COMPLEXITY SCORE. A STRIKE-THROUGH MEANS THAT AN ELEMENT HAD BECOME LESS VALID IN THE PERIOD BETWEEN THE SURVEY AND THE IN-DEPTH INTERVIEW.

#	T	O	E	Top-3 element	Top-3 element	Top-3 element	C-score
1	3	1	2	Capacity and skills availability	Interfaces between different disciplines	Trust between the PDO and the contractor	57%
2	3	1	2	Capacity and skills availability	Contract type	Time pressure	43%
3	3	1	2	Discontinuity in staffing	Number of contracts and their interfaces	Time pressure	44%
4	3	2	1	Nature of the location	Diversity in stakeholders' interests	Interfaces with other projects	50%
5	3	1	2	Resource availability	Discontinuity in staffing	Time pressure	33%
6	3	1	2	~~Number of clients~~	Number of contracts and their interfaces	Time pressure	43%

All respondents mentioned the pressure created by the adjacent metro line as mayor contributing element to project complexity. Most respondents perceived this pressure as time pressure, but the project manager and project engineer also indicated organisational pressure because two PDOs were working on the same project. The pressure was also created due to the strong focus of the municipality on the metro-project and its delivery deadline: this empowered the metro line to intervene strongly in the bus station.
The civil client tried to manage this complexity by trying to establish a joint project bureau in which both parties would be represented thereby smoothening their interfaces. He, together with the interface manager, both suggested temporary solutions for the metro facilities as possibility to relieve pressure off the bus station. The construction manager created time by planning parts of the project parallel instead of sequential thereby minimising the room for error.

The second topic mentioned by almost all respondents (except for the project manager and construction manager) was the complexity due to the process of decision making. Several respondents mentioned the great number of municipal agencies as cause of this complexity because decision making was significantly harder with many parties defending their own 'kingdom'. The civil client perceived problems in the separation between the civil principal and the funding agency which caused a lack of ownership between all parties: he created this ownership by bringing them together in one consultation. The project manager tried to cope with this complexity by pro-actively creating solutions that could speed up the process of decision-making.

The third topic that was considered to be complex was the Project Delivery Organisation itself. Both project manager and civil client mentioned the lack of knowledge within the team, especially when it came to tendering. Other respondents indicated the discontinuity within the PDO was contributing to project complexity. This even became apparent within the process of interviewing: two of the six respondents were removed from the project during the research.
The project manager tried to manage this complexity by focussing his effort on his team and the interfaces within his team. He also kept in close contact with line-management of his own organisation in order to establish a sound PDO with a long-term commitment. He also increased redundancy by appointing assistants on every role in the team that could replace people if necessary. The civil client tried to support the project manager by arranging coaches for him, helping him in performing his job.

The D&C contract seemed to enhance the complexity within the project. The civil client deliberately enhanced project complexity by choosing this type of contract, believing that this would contribute to the quality of the project. He acknowledged the lack of experience within the PDO with this contract type but believed that the team should learn this way of tendering since it was more beneficial to society in general. The construction manager perceived this contract type as a complex factor, since the interfaces with the adjacent project became harder to manage for the team: details could only be discussed between contractors because they would be responsible for the design.

The project leader of the funding agency indicated the lack of financial resources as a complex element in the project and indicated this lack of resources as the main problem

within the project. The civil client however disagreed on this point and stated that there was too much money available for the project. This indicated noise in the problem formulation between actors, which was also experienced by the interviewer: it took all six interviews to fully comprehend the project and the different complexities that played a role within the project.

When it came to the interventions both the interface manager and project leader of the funding agency indicated that they felt powerless in managing these problems since they did not have direct influence in this process but were however affected by this complexity. Their contribution to the project was very limited since they were waiting for a decision before they could play an active role in the project: both had not received an official assignment since no decision had been taken.
The project leader of the engineering firm and the construction manager did play active roles in the project but they also felt like they had few possible interventions to manage the complexity. They did feel affected by the problems created due to project complexity.

5.1.2. *Implications and management of different perceived complexities*

Table 5.3 shows the scores of all respondents on the top-3 TOE-elements of the project manager. In this case, the respondents were only confronted with the difference on the first two elements since the project manager indicated that the element of 'trust between the PDO and the contractor' was not based on experiences within this specific project but within previous projects.

TABLE 5.3 SCORES OF RESPONDENTS OF CASE 1 ON THE TOP-3 ELEMENTS OF THE PROJECT MANAGER. THE NUMBERS CORRESPOND WITH THE NUMBERS GIVEN IN TABLE 5.1 THE PROJECT MANAGER IS PROJECTED IN THE ORANGE CIRCLE. A 0 MEANS 'NOT CONTRIBUTING TO COMPLEXITY' A 4 MEANS 'HIGHLY CONTRIBUTING TO COMPLEXITY'.

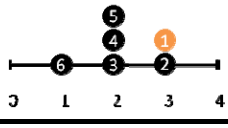
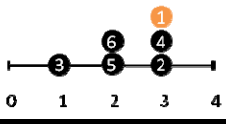
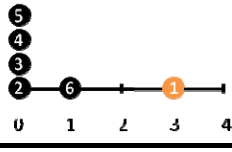
Capacity and skills availability	*Interfaces between different disciplines*	*Trust between the PDO and the contractor*
		

Table 5.4 shows the summary of the reactions of respondents on the questions about different perceived complexities.

TABLE 5.4 COMMENTS OF THE RESPONDENTS OF CASE 1 ON THE AWARENESS OF DIFFERENT PERCEIVED COMPLEXITIES, THE DIFFERENCE IN SCORES WITH THE PROJECT MANAGER AND ON THEIR OPINION ABOUT DIFFERENT PERCEIVED COMPLEXITIES

#	Aware?	Remarks on differences with the PM	Opinion on different perceived complexities
1	Yes	-	It is important to know the perceptions of each other in order to know where sensitivities lie
2	Yes	Element was not perceived as contributing to complexity above average: it is a normal element in each project	It is important to account for different perceptions within a team in order to complement each other
3	Yes	Realized that the perception of the PM is understandable	It is important to explain your perception to others. The question is how
4	Yes	Elements were not perceived as contributing to complexity above average: they are normal elements in each project*	Differences are not important but might cause a strategically advantage situation for one party
5	No	Not enough information available to judge these elements	*No judgement given*
6	Yes/No	Realized that the perception of the PM is understandable, but not enough information available to judge these elements	It is important to reduce differences by providing every team member with the same information

** the interviewer accidentally biased this respondent by telling the respondent by mistake that the score on the element 'interfaces between different disciplines' was low where it actually was equally high scored.*

> **Unanimity score: the unanimity score of this project was 63%, meaning that the respondents achieved unanimity within the survey of 63% based on all scores of all 57 elements.**

Two respondents, the construction manager and the project manager, indicated that the different perceived complexities were a negative item leading to problems in the execution of the project. The project manager indicated that he did not manage perceived

complexities actively in the project. The civil client however, who had a lot of experience in the construction industry, saw the differences as a positive contributor to the result but experienced difficulties in transferring his own perceived complexity. The same goes for the interface manager.

The civil client indicated multiple interventions to deal with different perceived complexities. Most important was his vision to surround himself with people that had different management styles and different perceived complexities. All perceived complexities in the team were accounted for by doing so. He also made use of interpreters between him and the PDO in order to transfer his own perceived complexity to the team.

The interface manager was confronted with different perceived complexities when he tried to communicate his own perception: that perceived complexity was rarely understood by others. The interface manager had a strong opinion about project complexity: he argued that not the technical challenges but the organisational challenges created project complexity, especially when it came to the ICT within projects. He argued that the ICT is not complex within a project but in order to design the ICT a good plan of usage is needed. This plan of usage explains the detailed usage of the project and can be used in order to design all required ICT systems. If this plan is absent, ICT is becoming complex since it has no funded plan to base itself on.
This view was however rarely understood by other actors in projects which resulted in a strong desire to find ways to exchange perceived complexities. The interface manager did however not found a way to do so.

The project leader of the engineering firm acknowledged differences in perceived complexities but did not think that this was always a problem: as long as all actors understood the complexity of the project there would be no problem. If however one of the parties understood project complexity better than others it could use this knowledge to create a strategically advantage position for itself. In the view of the project leader the perceived complexities were based on interests and could therefore not be altered or changed: they were seen as challenges to deal with.

The project leader of the funding agency was aware of different perceived complexities but indicated that she was not affected by these differences. This is because her role in the project was not active enough in order to be confronted with these different perceived complexities.

5.1.3. *Overall case conclusion*

Although the project did not look very complex on the surface all respondents indicated that the project was complex. Complexity was mainly created due to the organizational set-up of the civil principal, the inexperienced, split, and unstable PDO and the pressure created by the deadline of the adjacent metro line.

The perceived complexities within this case were notable unanimous: with a score of 63% and a great resemblance in the chosen top-3 elements the respondents agreed in high degree about project complexity. This complexity seemed to cause problems which hindered the progress of the project but the respondents did not agree on the necessary solutions to solve these problems and even contradicted each other in the suggested solutions: some said that more budget should be made available while others stressed the importance of shift decision making while again others emphasized the improvement of the skills of the PDO as crucial solution.

Project performance seemed to be affected by the perceived complexities since they led to a lack of interventions: when it came to actual interventions in order to deal with complexity, the problems in the project or to create future solutions, many respondents indicated that they felt powerless and had no interventions to deal with project complexity. They were affected in their role by project complexity but could not manage it. It looked as if the perceived complexities paralysed the respondents, feeling victims of a situation they could not influence or manage. Even the project manager felt powerless in some degree: he sometimes did not feel completely in control of the project and felt dependent on other parties in dealing with project complexity.

There were challenging opinions on the impact of different perceived complexities on project performance. Almost all respondents indicated the different perceived complexities

as a negative phenomenon, leading to poor project performance since they caused miscommunication and cost time and energy.
An exception to this opinion was the civil client. He was the only one that indicated that complexity could have a positive effect on the project (due to the D&C contract) and he was the only one that saw the different perceived complexities as beneficial to project performance. He was therefore also the only one who identified several ways to deal with them without trying to alter them.

5.2. Case report 2: new ship lock in rural area

This case covered the renewal of a lock. An existing floodgate had to be converted to a shipping lock close to a rural village. Besides the lock, a new bridge had to connect both sides of the water in order to connect a relatively busy road to the village. The total costs of the project were estimated at €50 million which made the renewal a relatively small project compared to other lock-projects.

There were challenges in the project when it came to the inland waterways. The lock had to be constructed in a channel with a dead end and with many water dependent companies behind the project. Since these companies needed regular supplies through inland waterways the construction could not hinder these inland waterways too much.

The project was tendered as a D&C contract and was awarded to a contractor. At the moment of research the contractor was busy designing the project in detail and construction had not been commenced yet. The design phase however led to a couple of problems: a legal process had been started up at the council of state because the public participation process had provided too little space for public participation according to the inland waterway agency. The Project Delivery Organisation and the constructor were also arguing on the detailed designs that the contractor delivered.

Project performance at the time was therefore judged as good, but the forecasted performance of the project was uncertain since there were some indications that progress was about to stall.

The civil principal in this case was a ministerial department and the Project Delivery Organisation was a public agency responsible for the water security. An important NGO in the project was the inland waterway agency, responsible for defending the interests of the inland skippers. The participating contractor functioned as main contractor with several sub contractors underneath.

The project manager suggested six respondents for this case; an overview of the different respondents is given in figure 5.2 and in table 5.5.

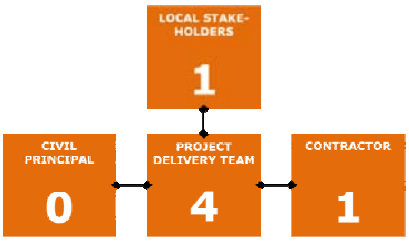


FIGURE 5.2 DISTRUBTION OF THE RESPONDENTS FROM CASE 2 ON ROLE-GROUPS

TABLE 5.5 OVERVIEW OF THE RESPONDENTS CASE 2

#	*Role*	*Stakeholder group*
1	Project manager	Project Delivery Organisation
2	Juridical advisor	Project Delivery Organisation
3	Contract manager	Project Delivery Organisation
4	Environment manager	Project Delivery Organisation
5	Regional coordinator inland waterway	Local stakeholder
6	Project manager	Contractor

5.2.1. *Perceived complexities and interventions dealing with that complexity*

The respondents showed different perceived complexities with all TOE-categories represented at the number one position and a wide variety in TOE-elements in the top-3 lists (table 5.6). The two problems that were described in the introduction formed the central parts in the interviews.

TABLE 5.6 OVERVIEW OF SURVEY-RESULTS OF CASE 2. THE NUMBER OF THE RESPONDENT IS INDICATED FOLLOWED BY THE RANKING OF THE TECHNICAL, ORGANIZATIONAL AND EXTERNAL ELEMENTS RELATIVELY TO EACH OTHER. THE TOP-3 TOE-ELEMENTS ARE THEN SHOWED FOLLOWED BY THE COMPLEXITY SCORE. A STRIKE-THROUGH MEANS THAT AN ELEMENT HAD BECOME LESS VALID IN THE PERIOD BETWEEN THE SURVEY AND THE IN-DEPTH INTERVIEW.

#	*T*	*O*	*E*	*Top-3 element*	*Top-3 element*	*Top-3 element*	*C-score*
1	2	3	1	~~Number of external stakeholders~~	~~Diversity in stakeholders interests~~	~~Social impact~~	44%
2	3	2	1	~~Diversity in stakeholders interests~~	Experience of stakeholders with LCPs	~~Social impact~~	48%
3	1	2	3	Number of goals	Uncertainty in methods	Technical risks	43%
4	2	2	1	Nature of the location	Number of external stakeholders	Diversity in stakeholders interests	33%
5	2	1	3	Capacity and skills availability	Resource availability	Contract type	48%
6	1	2	3	Diversity in technical disciplines	Quality requirements	Technical risks	60%

The project manager and juridical advisor experienced project complexity within the external elements, but since all interests had been translated into a contract which was awarded and construction had not been commenced, this complexity was not at hand anymore during the research. They also indicated that these external elements became the responsibility of the contractor from the moment of tendering the contract. The environmental manager however still experienced project complexity within the external elements. He managed complexity by organising different types of consultation in specific orders.

The project manager of the constructor did not experience the external elements as complex and criticised the modern trend that contractors were made responsible for environmental management. He also emphasized that construction had to be the central focus of the project: not environmental management.

Almost all respondents, except the juridical advisor, referred in some form to the contract when asked about project complexity. The criteria formulated in the D&C contract left room for interpretation and these differences in interpretations led to discussions between the PDO and the contractor: the PDO did not agree on the designs that were made by the contractor. This led to irritation on both sides of the table, although the contract manager indicated these discussions as a challenge in the project rather than a problem.

The project manager of the contractor questioned the type of contract: he indicated that every design had to be accepted by the PDO, leaving very little room for innovation: this was however a key concept of the D&C contract according to this project manager. He openly questioned the expectations put on constructors by PDOs: PDOs gave themselves more time to realise a design within the traditional contracts. Contractors received however too little time in order to create a solid design within integrated contracts.

The PDO and the contractor were unable to resolve their dispute and independent external parties had to be called in to resolve the conflict. The project manager also established a work office for the Project Delivery Organisation on the location of the project in order to enhance physical contact between the parties.

The coordinator of the inland waterways also questioned the type of contract, especially when it came to public participation: there was too little room for public participation because there was never a moment to talk about the details of a design since this design was part of the rewarded contract. She tried to deal with this complexity by enforcing participation through the council of state.

The juridical advisor also indicated complexity in the lack of public participation within this project. She explained that this project was the first one to be constructed under the New Water Act: all procedures were therefore new to all parties. The PDO, local governments and the contractor were unaware of this procedure and therefore there was a lack of opportunities to participate in the project. During the interview she emphasized the importance of public involvement in the decision-making process and that she realized that

the project became more complex by doing so: it was however her belief that this enhanced democratic value.
She handled this complexity by explaining the juridical implications of the New Water Act to all involved local stakeholders thereby enforcing public participation from the contractor. This however did not result in a better process and she judged the execution of the public law within the project as poor.

The coordinator of the regional waterways indicated project complexity as the lack of experience from the Project Delivery Organisation and constructors in designing locks. This lack of experience resulted in too few financial resources and designs of poor quality. She tried to deal with this complexity by providing information on shipping locks to all parties but experienced difficulties in the understanding of that information by these parties.

5.2.2. *Implications and management of different perceived complexities*

Table 5.7 shows all scores of all respondents on the top-3 elements of the project manager.

TABLE 5.7 SCORES OF ALL RESPONDENTS OF CASE 2 ON THE TOP-3 ELEMENTS OF THE PROJECT MANAGER. THE NUMBERS CORRESPOND WITH THE NUMBERS GIVEN IN TABLE 5.5. THE PROJECT MANAGER IS PROJECTED IN THE ORANGE CIRCLE, THE CONTRACTOR IN THE RED CIRCLE. A 0 MEANS 'NOT CONTRIBUTING TO COMPLEXITY' A 4 MEANS 'HIGHLY CONTRIBUTING TO COMPLEXITY'.

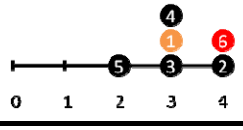
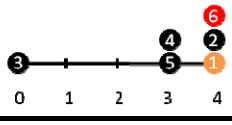
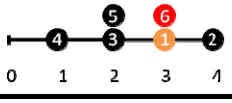
Number of external stakeholders	*Diversity in stakeholders interests*	*Social impact*
		

Table 5.8 shows the summary of the reactions of respondents on the questions about differences in perceived complexities.

TABLE 5.8 COMMENTS OF THE RESPONDENTS OF CASE 2 ON THE AWARENESS OF DIFFERET PERCEIVED COMPLEXITIES, THE DIFFERENCE IN SCORES WITH THE PROJECT MANAGER AND ON THEIR OPINION ABOUT DIFFERENT PERCEIVED COMPLEXITIES

#	*Aware?*	*Remarks on differences with the PM*	*Opinion on different perceived complexities*
1	Yes	-	Differences benefit the project performance and should be as different as possible
2	Yes	-	It is important to explain your perception to others
3	No	Elements used to be complex, not any more	It is important to have the same image of the project within the PDO
4	No	Did not agree on the element social impact	It is important to have the same image of the project within the PDO
5	Yes	Elements were specific elements for the project manager	It is important to account for different perceptions within a team in order to complement each other
6	Yes	Different judgements on external elements since there was a difference in available information between parties	It is important to know the perceptions of each other in order to understand each other

> **Unanimity score: the unanimity score of this project was 50%, meaning that the respondents achieved unanimity within the survey of 50% based on all scores of all 57 elements.**

The project manager indicated to experience differences in perceived complexities between the PDO and the civil principal. He indicated that civil principals determined complexity based on the costs of the project and the geographical position of the project: the further away from The Hague, the less complex the project becomes in the eyes of the civil principals. The Dutch administrative attention seems to be much more focussed on the large urban areas, such as the *Randstad*. The type of project had also implications for perceived complexities: highways received more attention than locks. These differences in perceived complexities resulted in a lack of attention for the project, forcing the project manager to continuously explain the complexity to the civil principals.
Within his team he tried to use perceived complexities in order to get a rich understanding of the project.

The juridical advisor indicated that different perceived complexities led to the depreciation of her knowledge area within PDOs. She continuously needed to explain the consequences of public law for the project to ensure a good execution of this law. She enforced listening if

necessary with the help of strong arguments or by using her superiors that could enforce listening.

The contract manager thought that it was important to exchange perceived complexities in order to communicate the same message from the PDO to the contractor. He mentioned the use of open questions in order to get to know perceived complexities.

The environmental manager did not experienced different perceived complexities within the PDO but did see different perceived complexities when he dealt with external stakeholders. It was important to know some of them but some stakeholders of the project only needed to be informed: complexity did not need to be explained in detail.

The coordinator of the internal waterways indicated that different perceived complexities were important in order to understand the total project. She however experienced difficulties in explaining her own perceived complexity and told that her vision was not always translated into the project.

The project manager of the contractor saw different perceived complexities as a possible threat within the project and indicated that it was the task of the PDO to make sure that they were all aligned at the start of the project.

5.2.3. *Overall case conclusion*

The perceived complexities focussed themselves on the external stakeholders and the implications of the contract. These perceived complexities seemed to drive interventions since almost the entire PDO did not felt the urge of managing the environment from the moment the constructor became formally responsible for this environment. To the opinion of the constructor the external elements were however of less importance than construction and these elements were therefore not managed at the same level as they were when the PDO was still responsible. This had no implications (yet) for project performance since the construction of the lock had not been commenced.

The respondents did not agree on the implications of different perceived complexities. The project manager and coordinator of internal waterways indicated that different perceived complexities lead to a better understanding of the project and therefore to better project performance. Others indicated that perceived complexities needed to be shared in order to prevent possible problems or to enrich the quality of the project. Nobody made comments on reducing the differences in perceived complexities.

Looking back, project performance could have been improved if all perceived complexities were taken into account at the right time within the project. If the contractor and PDO had exchanged perceptions during the tendering phase, differences on interpretations might have come to light. If the perception on the execution of the public law of the juridical advisor had been taken into account, a juridical process at the council of state might have been prevented. The same applied for the perceived complexity of the coordinator of the internal waterways on the design of the lock.
A remark can be made on the type of contract (D&C) within these situations: it seemed as if this contract reduced the possibility to exchange different perceived complexities within this case.

It is concluded that the lack of sharing perceived complexities, the lack of listening to them, sharing them too late and/or a combination of these factors increased project complexity and increased the chance on decreased project performance in the future.

5.3. Case report 3: new museum in rural area

The third case covers the construction of a new museum in a nature reserve. The museum would bundle multiple existing museums into one museum, which would not only consist of a museum but also of facilities around the museum that supported the function of the museum and an information kiosk about the surrounding natural reserve.

The museum was tendered with a DBFMO contract with an initial CAPEX of €160 million. A contractor was chosen based on competitive dialogues and became thereby responsible for the construction and 25-year during exploitation of the museum. The construction had been commenced during the research and the museum would be completed within a year. The biggest challenge for the project was a juridical procedure, put by a NGO protecting nature, because the nature in the area would be damaged too much due to the project. Just before the research started the council of state approved the zoning plan thereby giving green light for the project. The procedure however resulted in the delay of the construction of one of the facilities next to the museum.

The project performance was judged as excellent, because the project would be completed on time, within budget and with a good relation between the Project Delivery Organisation and the contractor. The delay in the facility next to the museum is judged as a minor issue compared to the total project performance.

The number of involved actors is large. A ministerial department functioned as civil principal, which also partly delivered the Project Delivery Organisation. Another governmental agency, responsible for governmental real estate, formed the other part of the Project Delivery Organisation: they were contracted by the ministerial department. The museum was located in the jurisdiction of two municipalities which both had interests in the project. The natural reserve was the property of the province and this actor was therefore also of importance to the project.

The process manager (who was the contacting person for this case) suggested six respondents for this case; an overview of the different respondents is given in figure 5.3 and in table 5.9.

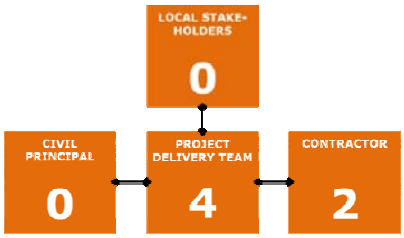


FIGURE 5.3 DISTRUBTION OF THE RESPONDENTS FROM CASE 3 ON ROLE-GROUPS

TABLE 5.9 OVERVIEW OF THE RESPONDENTS CASE 3

#	*Role*	*Stakeholder group*
1	Process manager	Project Delivery Organisation
2	Project leader municipality	Project Delivery Organisation (advisor)
3	Architect	Project Delivery Organisation
4	Project director	Contractor
5	Environmental manager	Contractor
6	Project manager	Project Delivery Organisation

5.3.1. *Perceived complexities and interventions dealing with that complexity*

The project was a utility construction projects that was executed with a DBFMO contract which resulted in different parties entering a long-term relationship with each other. The opinions of all involved actors can be found in table 5.10.

TABLE 5.10 OVERVIEW OF SURVEY-RESULTS FOR CASE 3. THE NUMBER OF THE RESPONDENT IS INDICATED FOLLOWED BY THE RANKING OF THE TECHNICAL, ORGANIZATIONAL AND EXTERNAL ELEMENTS RELATIVELY TO EACH OTHER. THE TOP-3 TOE-ELEMENTS ARE THEN SHOWED FOLLOWED BY THE COMPLEXITY SCORE. A STRIKE-THROUGH MEANS THAT AN ELEMENT HAD BECOME LESS VALID IN THE PERIOD BETWEEN THE SURVEY AND THE IN-DEPTH INTERVIEW

#	T	O	E	Top-3 element	Top-3 element	Top-3 element	C-Score
1	2	3	1	~~Nature of the location~~	~~Planning/juridical procedures~~	-	25%
2	2	3	1	Planning/juridical procedures	-	-	18%
3	2	1	3	Contract type	Time pressure	Trust between the projectteam and the contractor	45%
4	3	1	2	Contract type	Time pressure	Organizational risks	54%
5	2	1	3	Size of PDO	Capacity and skills availability	Time pressure	31%
6	2	1	2	~~Capacity and skills availability~~	~~Compatibility of different project management methods and tools~~	~~Time pressure~~	61%

The first mentioned topic on project complexity is the DBFMO contract. Both the project director and the environmental manager of the constructor indicated the time pressure, which consisted of the enforced discipline by the bank, as a complexity created by the DBFMO contract. The project manager also mentioned the responsibilities of the contractor to check the design with the output specifications combined with the new systems engineering skills the contractor had to learn as complex elements. The consortium dealt with the complexity by combining the DB and MO part into one organization which removed an interface between parties. Systems engineering was learned by the organisation in order to execute the contract according to the formulated output specifications and time was bought by executing more phases parallel to each other instead of sequential.
The architect also indicated project complexity caused by the PPS contract; this is because the design of the project was given out of hand which required trust between the PDO and the contractor.
The project manager saw the DBFMO contract as a way to deal with complexity: by using the knowledge of the market he did not need to acquire internal knowledge in order to realize the project.

The process manager and the project leader of the municipality saw the project complexity mainly in the juridical procedures that were started against the zoning plan. Both indicated that the consequences could have been massive if the project would not have won that dispute. Although the trial was completed during the research, the project leader still indicated the element as complex.

The process manager perceived the 'new' complexity within the time pressure on the project and the lack of cooperation from the province since they did not felt the urgency that the Project Delivery Organisation felt. This complexity was dealt with by talking en negotiating and eventually, if all would fail, by pressure from higher superiors. He indicated that elements are generally perceived as complex when actors cannot control the element. The project director of the constructor argued however the opposite: if something cannot be controlled it should not be perceived as complex.

The project leader of the municipality and the environmental manager both indicated complexity in the communication between the PDO (or constructor) and the civil principal. Due to a specific culture within the civil principal, communication was slow, inefficient and difficult.

The environmental manager did not perceived the project as complex: all challenges that were faced during the project were resolvable and therefore the project could not be called complex. The great number of employees was a challenge, which he managed by designing an extensive consultation structure that indicated who had to talk to who about what.

The project manager indicated that project complexity had not been reduced over time but the mentioned elements had become less valid because they referred to phases of the project which were already completed during the interviews. The time pressure that he felt during the survey was still present but became the responsibility of the contractor/consortium.

All respondents indicated that the good level of collaboration between all actors was one of the key success factors in managing project complexity. The project manager deliberately steered on elements such as a good atmosphere and the right tone between parties during the dialogue phase. The process manager indicated that the good connection between individual people was already created during that dialogue phase. The architect described the involved practitioners as people that wanted to perform and were willing to take the extra step. Several respondents indicated that all people had fun in what they did and that this fun contributed to the positive collaboration.

5.3.2. *Implications and management of different perceived complexities*

Different perceived complexities were acknowledged from the very beginning of the project and resulted in a great awareness among the respondents on these differences. The differences between the respondents and the process manager are shown in table 5.11.

TABLE 5.11 SCORES OF ALL RESPONDENTS OF CASE 3 ON THE TOP-3 ELEMENTS OF THE PROCESS MANAGER. THE NUMBERS CORRESPOND WITH THE NUMBERS GIVEN IN TABLE 5.9. THE PROCESS MANAGER IS PROJECTED IN THE ORANGE CIRCLE, THE CONTRACTORS IN THE RED CIRCLES. A 0 MEANS 'NOT CONTRIBUTING TO COMPLEXITY' A 4 MEANS 'HIGHLY CONTRIBUTING TO COMPLEXITY'.

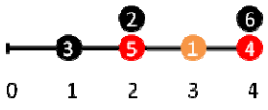
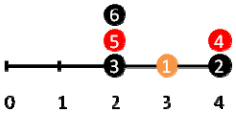
Nature of the location	*Planning/juridical procedures*
	

Table 5.12 shows the summary of the reactions of respondents on the questions about differences in perceived complexities.

TABLE 5.12 COMMENTS OF THE RESPONDENTS OF CASE 3 ON THE AWARENESS OF DIFFERENT PERCEIVED COMPLEXITIES, THE DIFFERENCE IN SCORES WITH THE PROJECT MANAGER AND ON THEIR OPINION ABOUT DIFFERENT PERCEIVED COMPLEXITIES

#	*Aware?*	*Remarks on differences with the pm*	*Opinion on different perceived complexities*
1	Yes	-	Differences are essential in finding the problems within the project
2	Yes	There was no difference in judgement: only in definition.	Sharing perceived complexities is essential in project performance.
3	Yes	Elements were not perceived as contributing to complexity since they were not the responsibility of the respondent	One hopes that everybody sees the same; agreement is important
4	Yes	Elements were out of the influence range of the respondent	Interests need to be exchanged in order to skip the conflict phase
5	Yes	Elements are not perceived as contributing to complexity	Different perceived complexities have no consequences for the project, only different interests
6	Yes	Elements should have been scored higher in retro perspective	Differences lead to additional understanding of risks

> **Unanimity score: the unanimity score of this project was 51%, meaning that the respondents achieved unanimity within the survey of 51% based on all scores of all 57 elements.**

The process manager saw different perceived complexities as a way to deal with the problems within projects and argued that trust between parties is essential in order to share perceived complexities with each other. Trust was build with a vulnerable attitude towards the contractors. The right attitude in the collaboration proved to be important, not the focus on time, scope and money: problems generally show themselves within these elements but are not caused there. He indicated that perceived complexities between the PDO and the consortium/constructor were explicitly shared. Between the province and the consortium the perceived complexities were however implicitly shared, meaning that they were never clearly formulated: this led to the earlier mentioned problems between the province and the consortium.

The process manager and the project director both indicated that the negotiations could end in an agreement to disagree. The dispute was then placed outside the meetings in order not to hinder the overall progress: a solution had to be found elsewhere then. The project director mentioned the explanation and understanding of different interests as a crucial precondition in order to agree to disagree: this understanding led to collaboration because the conflict-phase could be skipped.

The project leader of the municipality mentioned the exchange of different perceived complexities as a crucial factor in project success because it enabled actors to explain the perceived complexity of others within their own organisations. By providing space for other perceived complexities in the execution of the project the good collaboration was ensured: pleasant conversations also contributed to this good collaboration.

The architect explained that he managed complexity by reaching a consensus on the core of the assignment with important project actors. An integral design was achieved by ensuring that everyone had the same vision.
He also argued that it is important to reach consensus on the core of the design assignment: when everybody has the same vision on an integral design solution they can work from that vision: the success of this process however depends on the involved people.

The environmental manager indicated that different perceived complexities did not influence project performance and should not be allowed to do so: an intervention should not be made dependable on the 'complexity score' of the project. Generally there are simply challenges that need to be dealt with, regardless of the perceived complexity.

The project manager mentioned different perceived complexities as crucial in assessing a complete picture of the risks of the project. He created an ambience in which they were shared with each other during the dialogue phase and this provided a sustainable basis for their collaboration throughout the project.

5.3.3. *Overall case conclusion*

This case seemed to have all the ingredients for poor project performance: an innovative contract design for this type of project, an inexperienced contractor with this contract type, the first construction project in a protected natural reserve and an inexperienced civil principal on the subject. The complexity was even more enhanced when the zoning plan was almost rejected by the council of state.

The respondents were however very positive on project performance. Every respondent mentioned complexities which were role-specific and all respondents indicated one or more interventions that were used to deal with these complexities. Even the threat of a 'show-stopper' did not tempted respondents to alter their perceived complexities on the situation, thereby showing faith in each other: people were confident that the right person would deal with the complexity in the right way. All respondents therefore kept very close to their own role in the project when it came to their perceived complexities.

The several interventions dealing with complexity mentioned by the respondents were all logical consequences of the perceived complexities of those respondents. Together they formed an extensive set of interventions that was used to deal with complexity.

It is therefore concluded that project performance was positively influenced due to different perceived complexities. This was also indicated by almost all respondents, with a strong exception for the environmental manager: he argued that different perceived complexities had zero influence in the project. All other respondents however emphasized the fact that the explicit exchange of them was already a topic during the dialogue and remained an important part of the contact between the parties. Not only did the respondents indicate that different perceived complexities made a richer picture of the project (and risks), they also indicated that problems in the communication were avoided by an early exchange of these perceived complexities and the interests that the practitioners represented in the project.

5.4. Case report 4: new metro station in urban area

This case consisted of the construction of a new metro station in the middle of a large city centre. The new station would become part of a new metro line constructed through the city. With a length of several kilometres through soft soil and multiple deep stations constructed in urban area, the project could be called unique in its kind.

The entire project had a long and restless history with the start dating back decades before the research. The total project had gone hugely over budget and time and a full description of the projects' moving history would be too extensive for this research. This description will therefore focus on the metro station itself and the recent history.

The construction of this metro station always accounted for much resistance within the neighbourhood of the project. Occupants and retailers objected to the construction since it would disturb the neighbourhood too much. Several years before the research, during the construction of the underground station, several houses on the surface prolapsed 25 centimetres within an hour. Construction was stopped and a committee conducted research on the matter if it was responsible and safe enough to even move on and finish the project. The committee decided that the project had to be finished but the environment had to be taken much better into account. Budget was made available in order to do so and the practitioners within the project bureau (being the Project Delivery Organisation) were replaced.

Since then project performance was improved. The relation with the neighbourhood became much better and progress was re-established. The media attention for the project cooled down and at the time of the research it looked as if the new deadline would be reached within the renewed estimated costs.

The actors involved in this research are the Project Delivery Organisation (organised in a separate project bureau); the NGO that defended the interests of the neighbourhood and the contractor responsible for constructing the station (being part of a larger contract that includes three stations in total). The project was ordered by the municipality, which also contributed the largest share of the budget.
It must also be said that the spokesman of the NGO, also respondent in the research, was paid for by the project bureau: this decision was part of the interventions done by the committee. The spokesman became responsible to defend the interests of the neighbourhood; this used to be the responsibility of the project bureau.

The project manager suggested five respondents for this case; an overview of the different respondents is given in figure 5.4 and in table 5.13.

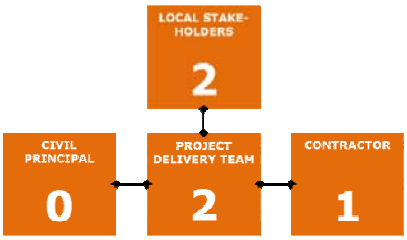


FIGURE 5.4 DISTRUBTION OF THE RESPONDENTS FROM CASE 4 ON ROLE-GROUPS

TABLE 5.13 OVERVIEW OF THE RESPONDENTS CASE 4

#	*Role*	*Stakeholder group*
1	Project manager	Project Delivery Organisation
2	Project director	Contractor
3	Spokesman NGO	Local stakeholder
4	Environmental manager	Project Delivery Organisation
5	Chairman NGO	Local stakeholder

5.4.1. *Perceived complexities and interventions dealing with that complexity*

The project experienced large problems in the past and was therefore temporary brought to a full stop. Together with a new PDO a new way of communication with the environment was introduced and performance was improved. This was reflected within this research because the perceived complexities changed severely between the moment of the survey and the in-depth interviews: almost all respondents indicated that their originally selected TOE-elements became less valid. The results are shown in table 5.14.

TABLE 5.14 OVERVIEW OF SURVEY-RESULTS FOR CASE 4. THE NUMBER OF THE RESPONDENT IS INDICATED FOLLOWED BY THE RANKING OF THE TECHNICAL, ORGANIZATIONAL AND EXTERNAL ELEMENTS RELATIVELY TO EACH OTHER. THE TOP-3 TOE-ELEMENTS ARE THEN SHOWED FOLLOWED BY THE COMPLEXITY SCORE. A STRIKE-THROUGH MEANS THAT AN ELEMENT HAD BECOME LESS VALID IN THE PERIOD BETWEEN THE SURVEY AND THE IN-DEPTH INTERVIEW.

#	T	O	E	Top-3 element	Top-3 element	Top-3 element	C-Score
1	2	3	1	Nature of the location	Social impact	Media influence	68%
2	1	3	2	~~Goal alignment~~	~~Uncertainties in the scope~~	Technical risks	60%
3	1	1	1[4]	~~Experience of stakeholders with LCPs~~	Social impact	~~HSSE awareness~~	88%
4	2	3	1	-	-	-	11%
5	2	1	3	~~Capacity and skills availability~~	~~Quality of the contract~~	~~Trust between the projectteam and the contractor~~	71%

The respondents that were experienced both the old and the new PDO indicated two major interventions that re-established the progress of the project done by the PDO: (1) the improvement of the relationship between PDO and contractor and (2) the centralisation of the interests of the environment within the project. Problems were managed and reduced due to the open and transparent approach of the new PDO. They made the first move in improving the relationship and this move was followed by the NGO and the contractor.

The project manager mentioned primarily external elements as mayor contributors to project complexity because they could not be fully managed. The interests of the civil principal became much more focussed on the environment around the project due to the prolapsed buildings. The project manager managed complexity by introducing a new way of communicating, focussing on the communication of risks and uncertainties instead of solutions and by managing perceived complexities. The overall project-management-board of the metro line also decided to introduce a new communication channel: workmen constructing the tunnel explained the project to the neighbours of the project. This led to much more understanding between the parties.
He also indicated that the perceived complexities of people made reality and they therefore needed to be the basis of project management. Solutions were not found in tools but in people: the right project management team made a difference. It was therefore important that practitioners would have fun in the project and in their job.

The project director of the constructor indicated complexity within the difficult relation with the PDO. The new project manager made the scope however more clear and aligned the goals which led to a reduction of complexity because there was a feeling of control. The technical risks would always stay a complex element but could be managed by hiring well educated people to deal with these risks. He emphasized the necessity for a contractor to make profit: if there was no profit, the company would get restless and send in extra people thereby increasing complexity.
Complexity was furthermore managed by mirroring the organisation of the PDO to the organisation of the contractor: counterparts thereby became clear and this led to more organisational clarity.

Both the spokesmen and the contractor indicated the importance of the mature commissioning of the project to a contractor. The PDO in this case did indeed not outsource all responsibilities but kept involved, especially on the topic of management of the environment.

[4] The respondent indicated in the interview that the external TOE-elements were the main contributors to project complexity. The interview therefore focussed on the top-3 external elements

This environment was managed with the help of several interventions. The chairman explained that construction decency had increased significantly and the spokesman mentioned the centralisation of the environment in the project management as a crucial intervention. It is however noteworthy that both respondents of the NGO indicated that these interventions actually increased project complexity because the organisational and technical elements of the project became more complex.
The spokesman furthermore criticised the initial decision to make the project bureau responsible for both project result and environmental management: it was impossible for the project bureau to serve both interests with full attention. The decision to split this responsibility and make the NGO responsible for defending the interests of the environment was therefore a good intervention in managing complexity.

The environmental manager of the project did not perceived the project as complex from her own role. This is because the management of the environment became 'second nature' within the PDO, which indicated that this task was not perceived as difficult or challenging.

5.4.2. *Implications and management of different perceived complexities*

The project manager indicated an important role for perceived complexities within project management. The scores of all respondents on the top-3 TOE-elements of the project management are showed in figure 5.15.

TABLE 5.15 SCORES OF ALL RESPONDENTS OF CASE 4 ON THE TOP-3 ELEMENTS OF THE PROJECT MANAGER. THE NUMBERS CORRESPOND WITH THE NUMBERS GIVEN IN TABLE 5.13. THE PROJECT MANAGER IS PROJECTED IN THE ORANGE CIRCLE, THE CONTRACTOR IN THE RED CIRCLE. A 0 MEANS 'NOT CONTRIBUTING TO COMPLEXITY' A 4 MEANS 'HIGHLY CONTRIBUTING TO COMPLEXITY'.

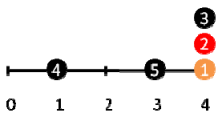
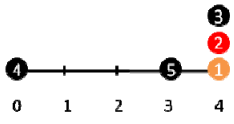
Nature of the location	*Social impact*	*Media influence*
		

Table 5.16 shows the summary of the reactions of respondents on the questions about differences in perceived complexities.

TABLE 5.16 COMMENTS OF THE RESPONDENTS OF CASE 4 ON THE AWARENESS OF DIFFERENT PERCEIVED COMPLEXITIES, THE DIFFERENCE IN SCORES WITH THE PROJECT MANAGER AND ON THEIR OPINION ABOUT DIFFERENT PERCEIVED COMPLEXITIES

#	*Aware?*	*Remarks on differences with the PM*	*Opinion on different perceived complexities*
1	Yes	-	The different perceptions contribute to understanding and managing different is a key concept in modern project management
2	Yes	Elements were recognized but judged differently due to differing primary responsibilities.	It is important to create understanding by sharing perceptions, in order to avoid collisions.
3	Yes	*- No differences in scoring -*	There must be accordance on the crucial project elements
4	Yes	Elements were not perceived as complex because there was enough goodwill that functioned as buffer	It is important to understand perceptions but it is not necessary to reach consensus
5	Yes	*- No confrontation with differences due to a lack of time in the interview -*	It is important to exchange perceptions in order to create trust.

Unanimity score: the unanimity score of this project was 32%, meaning that the respondents achieved unanimity within the survey of 32% based on all scores of all 57 elements.

The project manager indicated that the exchange of perceived complexities was vital in project management, since it were these that required action, not the facts of the project. Different perceived complexities within the PDO were important for project success and the project manager indicated that he would replace people if they tended to be alike. The result of managing perceived complexities was not agreement but understanding and awareness. This was done by forcing actors to ask each other open questions.

The project director of the contractor indicated that the exchange of perceived complexities resulted into understanding. Different perceived complexities originated in different primary

responsibilities and therefore variety was seen as natural: they could however lead to conflicts if there wouldn't be understanding for each others' perceived complexities.

The spokesmen of the NGO noted that it was important that agreement was reached on the vital project elements.

The environmental manager was aware of different perceived complexities but did not experience any influence of those differences on her work.

The chairman of the NGO translated the different perceived complexities into differences in experience. He indicated that conversations with the project manager about these differences led to understanding the experience of the other, which led to trust between the parties. These conversations focused themselves on the exchange of experiences without mitigating or altering arguments of one another.

5.4.3. *Overall case conclusion*

External complexity led initially to huge problems within this project and even threatened the very completion of the project. A break-through was constructed in the progress of the project with the instalment of a new Project Delivery Organisation: by focussing project management on the environment and the relation with the contractor, the new project manager re-established progress.
The validity of top-3 elements thereby decreased for all respondents that were no member of the PDO. The complexity even totally disappeared for the environmental manager. All respondents perceived the complexity from their own role within the project and the unanimity score was the lowest of all five cases (but strongly influenced by the low scores of the environmental manager). All respondents indicated several interventions to deal with their perceived complexities, which illustrated the feeling of progress in the project.

So the PDO managed to cope much better with complexity due to a new project management style. This style was, according to the project manager, based on the management of perceived complexities. All respondents were indeed aware of differences and three respondents indicated that different perceived complexities led to a positive project performance. Noteworthy are the remarks on the effects of the interventions: they sometimes increased complexity within the project on other project components (technical and organisational) according to respondents.

It is therefore concluded that different perceived complexities had a positive influence on project performance within this case. A new way of project management, based on perceived complexities, was applied and turned out to be vital for the progress of the project. The crucial factor in this new management was the PDO and more specifically the project manager.

5.5. Case report 5: expansion of a train station

The last case consisted of the renovation and expansion of a train station. The train station had to be expanded in order to cope with a growing amount of trains landing on the station. A new platform had to be constructed together with the necessary rail infrastructure. A new pedestrian tunnel was also constructed underneath the train station at the same time. This tunnel was originally planned two years after the construction of the platform but it was decided that both would be brought to the market in one D&C contract.

The project was awarded and construction had been almost completed during the research. The platform was realised on time, under high pressure of another project, but the tunnel was not finished on time and the carcass still needed to be delivered during the research. There were also some difficulties in the relation with the constructor: friction between the PDO and contractor resulted in a poor collaboration and it was decided to prematurely terminate the contract with the contractor. This was caused due to a lack of trust between the parties which was caused by a specific event.
This resulted in the re-tendering of a part of the contract for the completion of the pedestrian tunnel (the carcass was going to be finished by the original contractor).

The re-tendering of the contract also provided the opportunity to reconsider the scope of the project because the contract could be reformulated. This decision to reconsider was based on new information in which it became clear that more trains were desired and the

current emplacement around the station did not meet standards necessary to provide these extra trains. The civil principal therefore ordered new research on the scope and possible solutions.
A new scope was formulated by the PDO and translated into three possible scenarios for future construction. These scenarios were submitted to the civil principal. A new discussion followed between PDO and civil principal: the civil principal was prepared to provide only half the financing asked for by the PDO.

The project performance of this project was judged as medium: dynamic complexity clearly indulged within this project, leading to several major events that made a strong impact on the project. The project was therefore over time and over budget and in two phases at the same time. It was however still able to make some form of progress whatsoever, never ending up in a dead-lock.

The number of actors in this case was again large. A ministry department functioned as civil principal together with the organisation responsible for the rail infrastructure. This same organisation also delivered the PDO, which made the organisation both civil principal and Project Delivery Organisation. Involved provinces and rail carriers were important stakeholders in determining the new scope and during the construction phase (de-activation of scheduled trains was an important aspect of the project).
Multiple external stakeholders were united in a sounding board providing the Project Delivery Organisation with advice and participating in decisions. One of those external stakeholders was an association which defended the interests of the greenery around the station. The chairman of this association, who was also a member of the sounding board, participated in the research.

The project manager suggested seven respondents for this case; an overview of the different respondents is given in figure 5.5 and in table 5.17.

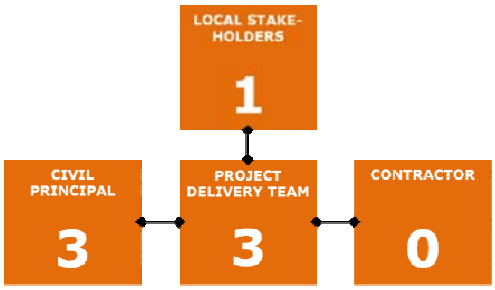


FIGURE 5.5 DISTRUBTION OF THE RESPONDENTS FROM CASE 5 ON ROLE-GROUPS

TABLE 5.17 OVERVIEW OF THE RESPONDENTS CASE 5

#	*Role*	*Stakeholder group*
1	Project manager	Project Delivery Organisation
2	Program manager at ministerial department	Civil principal
3	Project manager at engineering firm	Project Delivery Organisation
4	Infrastructure advisor at rail carrier	Civil principal (advisor)
5	Program manager at rail-infra manager	Civil principal
6	Plan developer	Project Delivery Organisation
7	Member of the sound-board; chairman of greenery association	Local stakeholder

5.5.1. *Perceived complexities and interventions dealing with that complexity*

Respondents showed a wide variety in perceived complexities and interviews tended to focus on either the 'old' scope or on the 'new' scope (as referred to in the description of the case). An overview is given in table 5.18.

TABLE 5.18 OVERVIEW OF SURVEY-RESULTS FOR CASE 5. THE NUMBER OF THE RESPONDENT IS INDICATED FOLLOWED BY THE RANKING OF THE TECHNICAL, ORGANIZATIONAL AND EXTERNAL ELEMENTS RELATIVELY TO EACH OTHER. THE TOP-3 TOE-ELEMENTS ARE THEN SHOWED FOLLOWED BY THE COMPLEXITY SCORE. A STRIKE-THROUGH MEANS THAT AN ELEMENT HAD BECOME LESS VALID IN THE PERIOD BETWEEN THE SURVEY AND THE IN-DEPTH INTERVIEW.

#	T	O	E	Top-3 element	Top-3 element	Top-3 element	C-score
1	3	1	2	Number of clients	Number of financial resources	Organizational risks	64%
2	1	3	2	Clarity of goals	Uncertainties in the scope	Dependency between subprojects	43%
3	2	1	2	Capacity and skills availability	Interfaces between different disciplines	Trust between the projectteam and the contractor	60%
4	2	1	2	Contract type	Experience with parties involved	Trust between the projectteam and the contractor	74%
5	2	3	1	Diversity in stakeholders interests	Influence of stakeholders within the internal organization	interfaces with other projects	52%
6	3	2	2[5]	Number of external stakeholders	Experience of stakeholders with LCPs	Influence of stakeholders within the internal organization	50%
7	3	1[6]	1	Resource availability	~~Discontinuity in staffing~~	~~Cultural differences~~	63%

The project manager indicated three TOE-elements that focused on the civil principal. The number of clients and the number of financiers made the project complex for him. He reduced complexity by making the project components more sequential thereby being aware of the consequences for the deadline. He furthermore emphasized the fact that it was important to tell the 'project story', which can explain the complexity of the project in clear terms to other actors.

Almost all respondents, except for the member of the sounding board and the infrastructure advisor of the rail-carrier, indicated complexity as the process of re-stating the scope (i.e. the 'new' project). The program manager dedicated this complexity to time pressure created by politicians that demanded a new scope. This caused a shift in ownership from the rail-infra manager to the ministry and affected the technical components of the project. He dealt with complexity by communicating with all parties.
The program manager of the rail-infra manager indicated the project complexity as the process of aligning every stakeholder into a new project scope. She managed complexity by disconnecting process and content: in meetings she became the process leader and she appointed a colleague as the defender of her organisational interests.

All three respondents of the rail-infra manager mentioned their own organisation as a contributor to complexity. Due to re-organisations, renewed policies or powerful individuals, the project performance was impacted. The project manager dealt with this complexity by creating his own internal and informal network which he used to get things done.

Both the project director of the engineering firm and the advisor of the rail carrier looked in retro-perspective to the friction with the constructor when indicating project complexity. The project director argued that a lack of expertise combined with a lack of trust resulted in an atmosphere in which collaboration was not possible anymore. The used intervention was the termination of the contract. She also indicated that the contract type (D&C) led to difficult interfaces between two companies: it contributed therefore to complexity and therefore to the problems.
The advisor of the rail-carrier also mentioned the discontinuity in the PDO as a problem and did indicate very little interventions to deal with the project complexity.

[5] The respondent indicated in the interview that the external elements were the main contributors to project complexity. The interview therefore focussed on the top-3 external elements

[6] The respondent indicated in the interview that the organisational elements were the main contributors to project complexity. The interview therefore focussed on the top-3 organisational elements

The plan developer strongly emphasized that project complexity was created due to the difficult and visionless decision making within the civil principal. The civil principal initially ordered new research on the scope of the project. When the PDO formulated the new scope with necessary resources they only received half of the financial resources necessary to realise this new scope: this would led to a project of poor quality according to the plan developer. Decision-making also took too much time to realize the assignment in an orderly way: this fact left little room to involve the environment for example in the designs of the new scope. He did not indicate interventions to deal with this complexity.

The member of the sounding board indicated that the sounding board was only involved by the PDO when the details of a decision had to be decided but not when the important decisions were actually being made. This reduced project complexity in his view but it also led to poor quality of the project. He did not indicate interventions to deal with this complexity.

5.5.2. *Implications and management of different perceived complexities*

The project manager emphasized the number of clients and financial resources at the civil principals as major contributors to project complexity. The scores of the other respondents on his top-3 TOE-elements are shown in figure 5.19.

TABLE 5.19 SCORES OF ALL RESPONDENTS OF CASE 5 ON THE TOP-3 ELEMENTS OF THE PROJECT MANAGER. THE NUMBERS CORRESPOND WITH THE NUMBERS GIVEN IN TABLE 5.17. THE PROJECT MANAGER IS PROJECTED IN THE ORANGE CIRCLE. A 0 MEANS 'NOT CONTRIBUTING TO COMPLEXITY' A 4 MEANS 'HIGHLY CONTRIBUTING TO COMPLEXITY'.

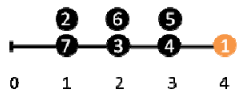
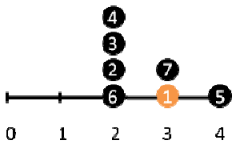
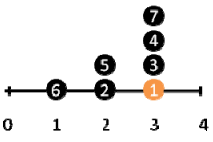
Number of clients	*Number of financial resources*	*Organizational risks*
		

Table 5.20 shows the summary of the reactions of respondents on the questions about differences in perceived complexities.

TABLE 5.20 COMMENTS OF THE RESPONDENTS OF CASE 5 ON THE AWARENESS OF DIFFERENT PERCEIVED COMPLEXITIES, THE DIFFERENCE IN SCORES WITH THE PROJECT MANAGER AND ON THEIR OPINION ABOUT DIFFERENT PERCEIVED COMPLEXITIES.

#	*Aware?*	*Remarks on differences with the PM*	*Opinion on different perceived complexities*
1	No	-	Differences need to be eliminated: unambiguous perceptions lead to better project performance
2	Yes	Elements were not perceived as complex since there was only one financer and one client	Different perceptions lead to difficulties in collaboration. Second opinions are sometimes necessary.
3	Yes	*- Respondent was not asked on differences with the PM -*	Differences can be used in order to generate a complete picture of the project
4	Yes	Element was not perceived as contributing to complexity above average.	When the complexities are not explained to people, problems occur
5	Yes/No	The element would be scored different in retro-perspective	Differences need to be understood in order to find the jointly goals
6	Yes	Elements were not perceived as complex or not contributing above average.	Differences lead to challenges in managing external stakeholders
7	Yes	Elements were judged differently due to different roles: political view vs. project view.	Differences need to be understood in order to create understanding

> **Unanimity score: the unanimity score of this project was 58%, meaning that the respondents achieved unanimity within the survey of 58% based on all scores of all 57 elements.**

The project manager indicated that different perceived complexities contributed negatively to project results and therefore needed to be eliminated. He used a tool to explain the complexity of the project to other people.

The program manager of the ministry experienced different perceived complexities between the ministry and the rail-infra manager. He indicated that the ministry depended on the

perceived complexity of the rail-infra manager and therefore needed a second opinion in some cases thereby indicating the importance of multiple perceived complexities on the project. The ministry installed a special 'translation desk' that checked all communication between the ministry and the rail-infra manager in order to prevent different perceived complexities from becoming a problem. He also mentioned a separate activity to get to know each other with two organisations as a valuable intervention.

The project director argued that underestimation of project complexity led to the ambition of combining the tunnel and the platform into one contract: if other perceived complexities were noted and taken into account this decision might not have been taken. She indicated that different perceived complexities led to a richer picture of the project (i.e. more information and understanding) but also needed calibration between parties once in a while: this was not done in the project. She also explained that it was important to ask the questions behind the questions.

Both the advisor of the rail-carrier and the program manager of the rail-infra manager indicated that the exchange of perceived complexities was necessary in order to prevent problems from occurring. The program manager emphasized that it was important to formulate jointly goals and that the exchange of perceived complexities led to understanding.
The importance of understanding is also mentioned by the member of the sounding board. He also indicated that perceived complexities did not always need to be explained but could be used to collect valid arguments which could be used at a time when they were necessary. Perceived complexities thereby became a strategic tool.

The plan developer experienced different perceived complexities within the external stakeholders. He managed these differences by focussing on the interests of people.

5.5.3. *Overall case conclusion*

Project complexity became apparent when the contract with the contractor was terminated and parties asked themselves if the scope of the project actually solved all the problems. Two different faces of project complexity became apparent: the first one created due to difficulties between the PDO and the contractor, the second one created due to difficulties between the PDO and the civil principal in the process of re-formulating the scope. Political powers within the civil principal seemed to affect the project and influenced the assignment of the PDO. A respondent of the PDO questioned if this new scope actually solved all the problems or that history was repeated.

The number of respondents that did not indicate a specific intervention for their perceived complexity is substantial which indicated project wide problems that were only manageable for a few. Other interventions were almost all focussed in dealing with the civil principals which emphasized the connection between a perceived complexity and interventions.

There were clues in this case that project performance was impacted by different perceptions. There was not enough space to exchange different perceived complexities in the communication between the PDO and the contractor according to a respondent. One respondent indicated that different perceived complexities could have prevented the problems created by combining multiple contracts.
The different perceived complexities between politics and project were also a clear indication of how different perceived complexities impacted project performance: the PDO had a great focus on the civil principals and experienced difficulties in the progress of the project due to these civil principals.

5.6. Conclusion

All case reports were verified with the project managers. The case reports were then used in order to provide the answers on the questions formulated in the introduction of this chapter.

5.6.1. *How can perceived complexities be described?*

A variant on the Brunswik Lens Model was designed in chapter two in order to describe the perceived complexities and this model turned out to be a useful tool to describe and better understand perceived complexities.

The hypothesis that the 57 elements of the TOE-framework could be seen as cues in the lens model turned out to be a workable hypothesis. These cues provided a starting point in the categorisation of the different comments that the respondents made while explaining the element.

It is noteworthy that almost all elements were translated into 'new' cues (i.e. *subjective* cues) thereby specifying what is meant by selecting the element. Some subjective cues were a logical interpretation of the original cues but other subjective cues were more difficult to relate to the original element. More than once the subjective cue turned out to be an element which was also available in the original list of 57 elements but was apparently not recognized by the respondent on first instance.

The perceptual judgement on each TOE-element was more difficult to filter out of the interviews. Subjective cues often provided a clue on these judgements and more then often the necessary link between the element of the respondent and the perceptual judgement on that element: without subjective cues the judgements would be difficult to comprehend.

Sometimes, in some very few interviews, the respondents also indicated an objective cue which could be seen as the 'source' of the selected element: the addition of the category 'objective cues' might provide a meaningful addition to the used lens model.

This shows the value of the lens model in combination with the TOE-framework: a clean display of the top-3 elements does not tell the full story since the subjective cues and perceptual judgements turned out to be crucial in understanding the perceived complexity of a practitioner. This especially becomes clear when the mentioned interventions to deal with a specific TOE-element are linked to this TOE-element: they often do not deal with the TOE-element but with the subjective cue or even with the perceptual judgement connected to the TOE-element.

It must however be emphasized that the combination of the TOE-framework and the lens model in its current form can only be used as a practical tool in order to describe and understand perceived complexities. The first use of this combination provided positive results but it needs much more scientific research before solid scientific conclusions can be drawn from the use of this model. This is a recommendation for future research.

Now that the lens model has been accepted as a valuable tool to describe perceived complexities the next questions pop up: why did respondents choose these three TOE-elements as their cues and why did they judge them the way they did? These questions will be answered in chapter six.

5.6.2. *How can perceived complexities of construction practitioners be categorised?*

Perceived complexities highly depend on the context of a project thereby making it difficult to give a general description of the perceived complexities of construction practitioners. This description would only be accurate for one specific project.

It is however useful to indicate which characteristics of the context lead to a certain perceived complexity. All respondents related their perceived complexity to certain characteristics within the project's context and on a case level it turned out that the respondents often used the same characteristics of this context in order to explain their perceived complexity.
Although these perceived complexities still differed greatly (making it difficult to conclude that a certain perceived complexity follows from a certain context characteristic) it is useful to know the context characteristics that are responsible in determining a perceived complexity: they could be used in future research and in practice when one would like to understand different perceived complexities within a project.

The contextual characteristics are the elements which were the elements mentioned by multiple or almost all respondents within a case. They are selected based on the case reports provided above and reflect the common thread within a case.
The overlapping context characteristics that are used in order to explain the perceived complexities within each case are summarised in table 5.21.

TABLE 5.21 SUMMARISED CONTEXT CHARACTERISTICS THAT WERE OVERALL MENTIONED WITHIN EACH CASE WHEN EXPLAINING THE PERCEIVED COMPLEXITY

Case	*Summarized context characteristics*
Case 1	A civil principal which has a fragmented organizational set-up An unstable Project Delivery Organisation which does not function optimally
Case 2	A great number of external stakeholders with (conflicting) interests A D&C contract which leaves room for interpretation
Case 3	A DBFMO contract A project location in the middle of a protected natural reserve
Case 4	A great number of external stakeholders with (conflicting) interests Construction within an urban environment
Case 5	Multiple civil principals that intervene in the project A D&C contract which was inflexible and created interfaces between parties

A clear distinction can be made between the five mentioned context characteristics: the characteristics of cases one, two and five refer to a component within the project which does not function as it supposed to do, or in other words: problems. The characteristics of cases three and four just refer to a certain component without judging this component as negative or positive: it was just 'simply' there and therefore needed to be managed.

This led to the conclusions that the perceived complexity can be based on characteristics that refer to problems within a project or just to characteristics of the project. The difference between these two types of perceived complexities which will be referred to as challenge-focussed or problems-focussed perceptions is shown in table 5.22.

TABLE 5.22 DIFFERENCE BETWEEN CHALLENGE-FOCUSSED AND PROBLEM-FOCUSSED PERCEIVED COMPLEXITIES

Challenge-focussed perceived complexity	*Problem-focussed perceived complexity*
Project complexity can contribute positively to the quality project	Project complexity contributes negatively to the project
Project complexity does not need to be reduced: it just needs to be dealt with	Project complexity needs to be minimized
Dealing with complexity is part of the daily routine in a project	Complexity needs to be managed once it threatens the progress of the project

5.6.3. *What is the link between perceived complexities and interventions dealing with project complexity?*

Another important phenomenon was found in the case reports: there was a strong contradiction between respondents that indicated interventions to deal with the top-3 TOE-elements and respondents who were unable to indicate interventions to deal with these top-3 TOE-elements.

The cause of this difference can be explained with the help of the *circle of influence*: if a respondent could mention interventions it meant that the respondent had the feeling it could deal with project complexity. Respondents that were unable to mention interventions mentioned TOE-elements which they could not manage due to lacking influence within the project. This difference is characterised as the difference between perceived complexities that lie either inside or outside the circle of influence of the respondent.

So the perceived complexities that were based on TOE-elements that lay outside the circle of influence of the respondents led to a lack of interventions to deal with this complexity. This shows a correlation between perceptions and interventions and provides enough evidence for the proposition that perceived complexities indeed influence interventions to deal with project complexity. The next chapter will answer the question *how* perceived complexities lead to specific interventions.

Four different types of perceived complexities can be derived by combining the two mentioned characteristics of perceived complexities. This is done in figure 5.6.

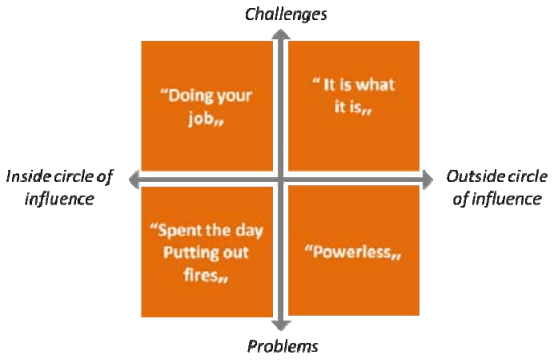


FIGURE 5.6 FOUR DIFFERENT TYPES OF PERCEIVED COMPLEXITIES

5.6.4. *What are the implications of different perceived complexities on project performance?*

The cases revealed strong indications that different perceptions impacted project performance. There was not enough evidence to formulate a solid theory on the causal relation between different perceived complexities and project performance but the project reports give enough clues in order to formulate the *proposition* that different perceived complexities indeed influence project performance. These clues will be formulated for each individual case below.

- Case one led to the assumption that a lack of different perceived complexities led to a lack of interventions and therefore impacted project performance. However, this is a weak proposition and needs additional evidence.
- Case two showed strong indications that in retro-perspective an exchange of different perceived complexities could have led to a better project performance and could therefore have prevented problems that occurred later on in the project.
- Cases three and four both gave enough reasons to believe that different perceived complexities made a positive contribution to project performance based on both the interviews and the observations and reflections made by the researcher.
- Case five contained some respondents that indicated that project performance was impacted negatively by different perceived complexities and an analysis of the problems led to the idea that different perceived complexities indeed led to problems between the most important project parties.

Besides these case results, many respondents indicated directly in the interviews that different perceived complexities impact project performance. This will be elaborated in chapter six, when the question *what* the implications of different perceived complexities on project performance are will be answered.

6. Results of the data analyses

Chapter five introduced the lens model as a framework which was used to describe perceived complexities. The why-question behind the perceived complexities remained however unanswered: why did the respondents choose their top-3 TOE-elements as cues and why did they judge them the way they did?

This chapter will answer those questions. By performing data analysis on the interviews, the descriptions of the perceived complexities and the case reports the following sub-research-questions will be answered:

- How do the different perceived complexities originate? *(sub-question B)*
- How do perceived complexities affect interventions dealing with complexity? *(sub-question E)*
- What are the implications of different perceived complexities on project performance? *(sub-question F)*

Explanation building was used in order to formulate seven hypotheses that were used to answer the first two research questions.

Descriptive research was used to describe the different management interventions dealing with project complexity.

The first section of this chapter will display the results of the explanation building (§6.1) followed by the results of the descriptive research (§6.2). The third section explains the connection between interventions and perceived complexities (§6.3). The conclusion will answer the formulated research questions (§6.4).

6.1. Results of the explanation building: formulating the hypotheses

Explanation building is used in order to find the 'why' behind phenomena (Yin, 2003). It is used in this research to find the origins of perceived complexities, the origins of differences in and the consequences of perceived complexities. Explanation building starts with an initial hypothesis which is validated within the data-set and altered if necessary to let the hypothesis comply with the data-set.

So how were the initial hypotheses formulated within this research? For the origins of perceived complexities this research used a pre-formulated *proposition*. For the origins of differences and the consequences of perceived complexities the tool of *coding* was used. Both are explained below.

The proposition formulated in chapter three that perceived complexities could be driven by role, education or interests of practitioners was used as initial hypothesis to explain the origins of perceived complexities. This limited the research on the sources of perceived complexities to these three components: they were based on common sense and confirmed by the practical and tacit knowledge of KING/RPA.

The initial hypotheses necessary for explaining the differences and consequences of perceived complexities were formulated with the help of coding (Bernard & Ryan, 2010): coding is the process of assigning certain parts of the interview minutes to certain categories. Parts of all interviews that refer to the same topic became comparable in this way. The minutes of the interviews were coded with the following codes:

- *The source(s) of perceived complexities*. These were remarks of the respondents that reflected upon the source and characteristics of their perceived complexity.
- *Source(s) of differences in perceived complexities*. These were remarks that reflected upon differences in perceived complexities and why these differences occurred. Any remarks about actions stimulating differences were also marked with this code.
- *The opinion on different perceived complexities*. These were remarks that gave some form of judgement on the differences in perceived complexities.
- *The consequences of different perceived complexities*. These were remarks of the respondents on the effects of differences in perceived complexities.

The interview minutes were paraphrased by the researcher after the codification of the minutes. It was necessary to paraphrase the fragments of the minutes to make the fragments comparable and more manageable for the research. All paraphrased fragments can be found in appendix D.

This process led to initial hypotheses which were then checked within the data-set according to the process of explanation building as described by Yin (2003). The data-set consisted of three data types: the minutes of the interviews, the descriptions of the perceived complexities (appendix B) and the case reports (chapter five).

There were three possible outcomes (when the initial hypothesis was checked within a source). All three possible outcomes are described below.

1. *The (general line of the) hypothesis was confirmed by the source*. If confirmed in total no adjustments were needed, if confirmed partly then the hypothesis was altered in order to fit the hypothesis with that data source and all the previous checked data sources.
2. *The hypothesis was rejected by the source*. If the source positioned itself in the total opposite of the hypothesis, the hypothesis was not altered but the source would be marked as rejecting.
3. *No comments were made by the source*. It is possible that no comments were made in an interview because the interview consisted of open questions and was of a qualitative nature: not all interviews were therefore 100% identical to each other.

This process made *hypotheses* from the *initial hypotheses*. The research then formulated a threshold to increase validity: this prevented that an explanation given by only one source would be considered as 'truth' or valid. A hypothesis would therefore be considered as a valid explanation if it would apply with one of the following two thresholds:

- If at least three different respondents divided over at least two different cases contributed to the hypothesis. Both confirmations and rejections counted as a comment. If this situation occurred then the discussion provided in chapter seven would elaborate on this contradiction.
- If the hypothesis was observed by the researcher in at least two different case reports.

This process of coding, categorising, interpreting, formulating and validating led to the formulation of seven hypotheses which all complied with the formulated threshold. These hypotheses are displayed in the text box below. The following paragraphs will elaborate in detail how each hypothesis was constructed.

FORMULATION OF THE HYPOTHESES

Hypothesis I: the selection of the TOE-elements is influenced by the impact of the elements on the project and the degree of control that the practitioner has on the project complexity: they occupy the mind of the practitioner.

Hypothesis II: the selection of the TOE-elements is influenced by experience of practitioners.

Hypothesis III: the selection of the TOE-elements is based on the contextual variables of the project.

Hypothesis IV: the judgement on the TOE-elements is influenced by the interests that the practitioner represents in a project. These interests are (partly) based on the role of a practitioner or on the personal values of a practitioner.

Hypothesis V: different perceived complexities originate in different levels of factual knowledge.

Hypothesis VI: different perceived complexities lead to diffused and ineffective efforts of actors and a bad collaboration, leading to poor project performance.

Hypothesis VII: different perceived complexities lead to a better understanding of the system, the risks and the problems of the project, leading to good project performance.

Table 6.1 shows the result of the explanation building process for all seven hypotheses. It shows which hypotheses were confirmed or rejected by which source. A justification of these contributions can be found in appendix D.

Table 6.1 also shows that some hypotheses were confirmed by much more sources than others: this creates the impression that some hypotheses are more valid than others. This is true to a certain extent but it should however not be forgotten that this research is a qualitative research: hypotheses therefore do not become necessarily more valid if they are mentioned by a larger number of sources because the total number of sources (30 respondents) is still too small to formulate solid proven hypotheses. A comment made by one respondent can be just as valuable as a comment made by thirty respondents, dependent on the level of insight or knowledge of the respondent.

All seven hypotheses, mentioned by many or few respondents, were therefore marked as equally valid but with the minor note that some hypotheses were confirmed by more respondents than others.

TABLE 6.1 RESULTS OF THE EXPLANATION BUILDING. EACH HYPOTHESIS IS CHECKED WITHIN THE INTERVIEWS (I) WITHIN THE DESCRIPDOIONS OF PERCEIVED COMPLEXITIES (DP) OR WITHIN THE CASE REPORT (CR). HYPOTHESES WERE CONFIRMED (WITH OR WITHOUT ALTERING) OR REJECTED. AN EMPTY CELL MEANS THAT NO STATEMENT HAS BEEN MADE IN THE SOURCE ON THE HYPOTHESIS.

	I: impact, control and occupation of mind		**II:** Experience		**III:** contextual variables		**IV:** Interests, roles and values		**V:** levels of factual knowledge		**VI:** differences lead to poor project performance		**VII:** differences lead to good project performance	
# resp.	*I*	*DP*	*I*	*DP*	*I*	*DP*	*I*	*DP*	*I*	*DP*	*I*	*DP*	*I*	*DP*
R1					C	C	C				C			
R2	C					C	C							
R3	C					C			C		C			
R4			C			C	C				C			
R5	C					C					R		R	
R6	C					C					C			
R7	C		C		C	C	C				C		C	
R8						C	C		C					
R9						C	C		C		C		C	
R10			C			C	C		C		R			
R11	C					C	C		C				C	
R12	C					C					C			
R13	C					C	C						C	
R14	C						C						C	
R15							C				C			
R16	C		C			C	C				R			
R17						R					R			
R18	C						C						C	
R19	C					C							C	
R20						C	C		C					
R21	C					C	C				C			
R22	C					C					R		R	
R23									C		C			
R24	C				C						C			
R25	C				C	C	C						C	
R26					C	C			C		C		C	
R27	C		C						C		C			
R28	C						C				C			
R29						C	C				C			
R30	C					C	C				C			
Case	*CR*		*CR*		*CR*		*CR*		*CR*		*CR*		*CR*	
1					C									
2					C									
3					C								C	
4					C								C	
5					C						C			

> **Hypothesis I: the selection of the TOE-elements is influenced by the impact of the elements on the project and the degree of control that the practitioner has on the project complexity: they occupy the mind of the practitioner.**

> **Hypothesis II: the selection of the TOE-elements is influenced by experience of practitioners.**

Hypothesis I was based on three different groups of comments that were found in multiple interviews. All three will be treated below.
The first group consisted of comments that dedicated the selection of TOE-elements to the impact of an element on the project. These comments often indicated these elements as the elements that caused problems in the project or the ones that the respondents perceived to make the greatest impact on the project.
The second group consisted of comments that dedicated the selection of TOE-elements to the occupation of the mind of the individual. These comments referred to the more than average occupation of time and energy of respondents, or to the fact that the selected elements were top of mind at the time over the interview.
The third group consisted of comments that dedicated the selection of the TOE-elements to the degree of control an individual has over an element. Peculiar is the contradiction in the answers within this group: respondents mentioned the lack of control as complex while

others mentioned the lack of control as not-complex since these elements do not lie within their sphere of influence.
An overview of respondents that contributed to this hypothesis is given in chart 6.1.

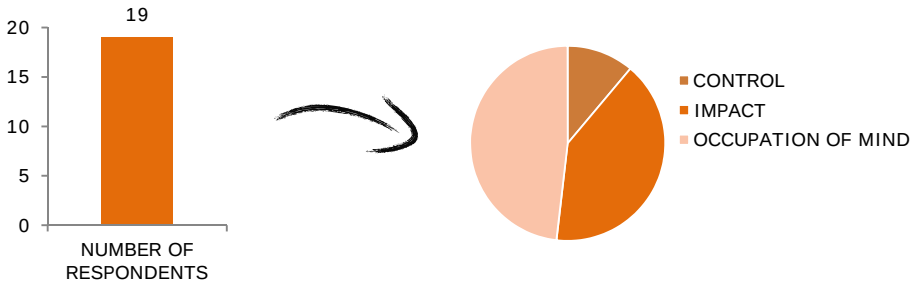


CHART 6.1 NUMBER OF RESPONDENTS CONTRIBUTING TO HYPOTHESIS I AND THE DISTRUBUTION OF THE SUB-ANSWERS WITHIN THE HYPOTHESIS (N=19).

It was chosen to combine the three groups of comments into one hypothesis because the topics of the three groups all interrelate: if an element makes a greater than average impact or has the potential make such an impact, the individual transfers its mind to that element and tries to control that element.
This interrelation between the groups was confirmed in seven interviews: these respondents mentioned a combination of the three groups or all three groups in one explanation as reasons for selecting their TOE-elements.

The hypothesis refers explicitly to the *selection* of TOE-elements, not to the judgement of the elements: the interview asked explicitly why the respondents *chose* these elements, not why they judged them the way they did.

Hypothesis II was purely based on the results of the explanation building within the interviews (chart 6.2).

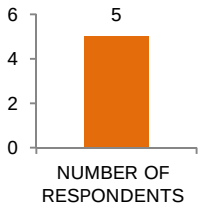


CHART 6.2 NUMBER OF RESPONDENTS CONTRIBUTING TO HYPOTHESIS II

The hypotheses were considered valid since the hypotheses were not directly contradicted in any interview, or in an interview-analysis or in a case report and both hypotheses complied with the rules for selection. This also applies to the three groups of comments that contributed to hypothesis I: each group complied individually with the formulated threshold.

> **Hypothesis III: the selection of the TOE-elements is based on the contextual variables of the project.**

Hypothesis III could already be expected based on chapter five (where a number of contextual variables that were commonly shared between respondents were identified within each case) and was indeed confirmed during the explanation building.

The hypothesis was based on several comments that had no connection at first sight but turned out to have one thing in common: they all related to contextual variables.
The contributing comments all had the same characteristics: they explained why other people would think different about complexity and on which elements these perceptions would differ. The respondents mentioned a total of six contextual variables which they indicated as sources of the perceptions of other people. An overview is given in chart 6.3.

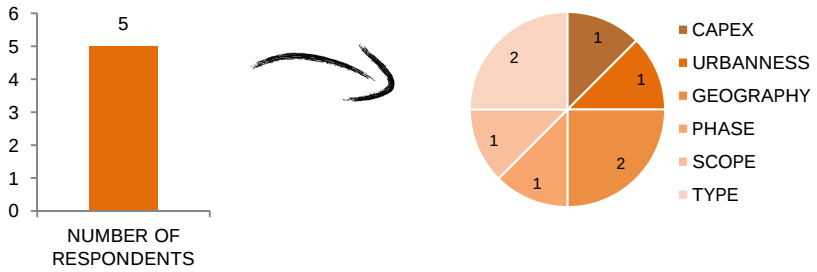


CHART 6.3 NUMBER OF RESPONDENTS CONTRIBUTING TO HYPOTHESIS III AND THE DISTRUBUTION OF THE SUB-ANSWERS WITHIN THE HYPOTHESIS (N=5).

The six mentioned contextual variables were not mentioned by enough respondents in order to formulate a hypothesis which complied with the formulated threshold. The common denominator was therefore selected as hypothesis, supported by the findings in the case reports in chapter five. The hypothesis complies thereby with the formulated threshold for selection.

The comments on the contextual variables were however insightful and provide information on how a context variable leads to a certain perceived complexity. These comments were:

- The *CAPEX* is mentioned as source since projects with a high CAPEX are judged more complex than projects with low CAPEX (note: the CAPEX is of course related to the size of the project, however, the CAPEX was mentioned explicitly as contextual variable).
- The *environment* is mentioned as source since a more urban environment is judged as a more complex environment than non-urban environments
- The *geography* is mentioned as source since projects that lie far away from the national political centre are judged less complex
- The *phase* is mentioned as source since different phases lead to different judgements on complexity
- The *scope* is mentioned as source since different scopes lead to different judgements on complexity
- The *type of project* is mentioned as source since one type of project is perceived more complex (e.g. a highway) than others (e.g. railroads)

The hypothesis refers again explicitly to the *selection* of elements, not to the *judgement* of the elements. This is because the respondents all mentioned the contextual variables as elements on which others base their perceived complexity and they thereby indicate that the contextual variables were *selected* as cues for a perception.

This hypothesis can be partly validated within the data by triangulating the hypothesis: all respondents were asked if their chosen top-3 TOE-elements were specific for the project they worked on. Based on the hypothesis it could be expected that the answer to this question would be 'yes' because perceived complexity are based on the context of a project and that context differs within each project. The answers are displayed in chart 6.4.

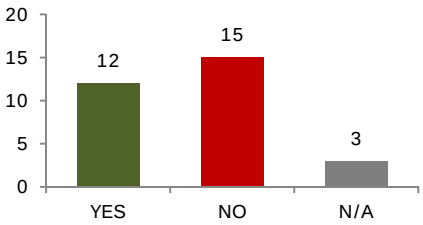


CHART 6.4 ANSWERS ON THE QUESTION "ARE THESE TOP-3 ELEMENTS PROJECT-SPECIFIC?" (N=30)

It turned out that that a small majority of the respondents answered "no". This could indicate that contextual variables are important causes of perceived complexities but not *the* most important cause. This possibility will be further elaborated in chapter seven.

> **Hypothesis IV: the judgement on the TOE-elements is influenced by the interests that the practitioner represents in a project. These interests are (partly) based on the role of a practitioner or on the personal values of a practitioner.**

Hypothesis IV was also based on three different groups of comments made by separate respondents. The hypothesis was however also found to a large extend within the descriptions of the perceived complexities (appendix B).

The three groups of comments that contributed to hypothesis IV are: comments that were made on the interests that practitioners represent within projects, comments that were made on personal values of practitioners and comments made on the role that practitioners had within a project. An overview of these three groups is given in chart 6.5.

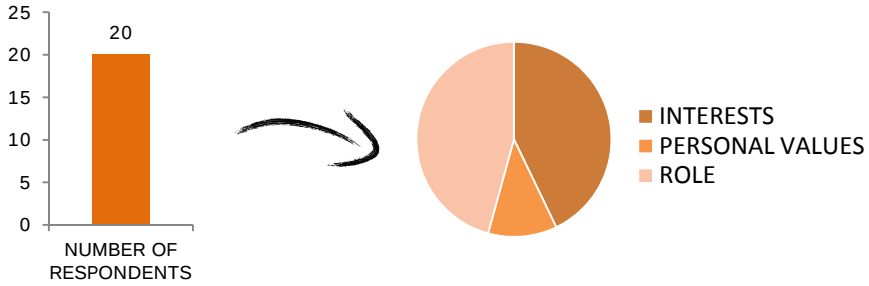


CHART 6.5 NUMBER OF RESPONDENTS CONTRIBUTING TO HYPOTHESIS IV AND THE DISTRUBUTION OF THE SUB-ANSWERS WITHIN THE HYPOTHESIS (N=20).

The first group of answers indicated interests of individuals as the source for perceived complexities. These interests are the interests the person is representing within the project, whatever interest that might be. Some respondents indicated that there were two categories of people when it came to interests: people that represent the interest of their own company/organisation and people that represent the interest of the project.
The second group of answers indicated personal values as source of perceived complexities. These respondents mentioned personal values as a motive behind the interest they represented. Mentioned values are for example the importance of public participation in decision-making or the importance of safety within projects.

> **"My approach is to realise the best possible project to society. Others choose the politically correct approach: this often results in reduced quality of the project„**
>
> *Interviewee — PDO member*

The third group of answers indicated the role of an individual as a source for perceived complexities. Mentioned examples were the differences between designers and contractors, between engineers and the rest of the world or between public and private parties. They all come down to the same proposition that the role of an individual in the project is a source for perceived complexity.

> **"Market parties think in terms of time and money. Public agencies think in quality„**
>
> *Interviewee — PDO member*

The decision to subordinate the *role* and the *personal value* of a practitioner to the *interest* of the practitioner was based on three arguments.
First, eight respondents mentioned a combination role and interest within the same interview.
Second, the descriptions of the perceived complexities (appendix B) showed that the interests of the respondent could very often be logically connected to the perceived complexity of the respondent.
Third, the descriptions of the perceived complexities showed that almost all descriptions of interests were based on the role or value of the respondent.

The relation between the role, personal value, interest and perceived complexity is graphically shown in figure 6.1.

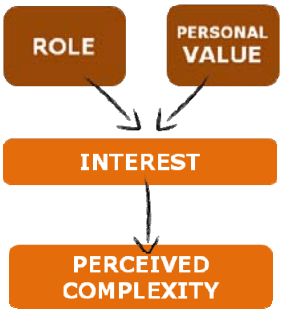


FIGURE 6.1 THE RELATION BETWEEN A ROLE, A VALUE, AN INTEREST AND A PERCEIVED COMPLEXITY

This hypothesis furthermore refers to the *judgement* of the TOE-elements, not to the *selection* of the TOE-elements. This was derived from the confrontation of respondents with the top-3 elements of their project manager: the respondents seemed to recognize the selected cues of the project manager as logical choices but indicated that they judged them differently due to differing roles.

The hypothesis was considered valid because the hypothesis complies with the threshold; all three sub-elements do as well and the logical connection between roles, values and interests was confirmed in the descriptions of the perceived complexities.

This hypothesis can also be partly validated within the data, again by applying triangulation. Because all respondents were asked if their top-3 of TOE-elements was role-specific (or in other words: would they have chosen the same top-3 elements if they had another role in the project?) it could be derived if the respondents agreed on the hypothesis: all respondents that indicated an interest based on their role were expected to answer "yes" to this question, all respondents that indicated an interest based on their personal value were expected to answer "no" to this question.
The respondents were therefore split into respondents that had a role-based interest and respondent that had a value-based interest. The results are shown in chart 6.6.

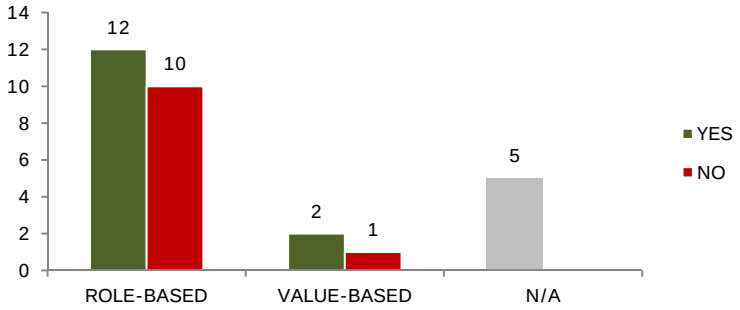


CHART 6.6 ANSWERS OF RESPONDENTS ON THE QUESTION "WOULD YOU INDICATE THE SAME TOP-3 WHEN YOU WOULD HAVE A DIFFERENT ROLE?" SPLIT ON ROLE-BASED-INTERESTS AND VALUE-BASED-INTERESTS (N=25).

Again the answers were not as expected. This could, just as with hypothesis II, indicate that interests are a cause of perceived complexity but not the *main* cause. This discussion will also be elaborated in chapter seven.

Hypothesis V: different perceived complexities originate in different levels of factual knowledge

Hypothesis V is purely based on the explanation building done within interviews. Ten respondents indicated that different levels of factual knowledge formed the basis of differences in perceived complexities. This knowledge mostly referred to technical knowledge: knowing how certain technical systems, techniques or methods work made a difference in perceived complexities according to respondents. The knowledge-level on organisational components, such as the contract or the risks, was also indicated as contributing to perceived complexities. In the opinion of most respondents the projects were perceived more complex when no knowledge was available on (parts of) the projects.

The decision not to indicate 'level of factual knowledge' as a source (but only as a source of differences) was deliberately made: eight of the nine respondents mentioned (the lack of) factual knowledge with *other* persons as a source of difference, not as a source of their own perception; only one respondent mentioned it as a source for his own perceived complexity.

Since this hypothesis complies with the formulated threshold it is considered to be valid.

> **Hypothesis VI: different perceived complexities lead to diffused and ineffective efforts of actors and a bad collaboration, leading to poor project performance.**

> **Hypothesis VII: different perceived complexities lead to a better understanding of the system, the risks and the problems of the project, leading to good project performance.**

Chapter five demonstrated that different perceptions impacted project performance: hypotheses VI and VII are the answers to the question *how* they impact project performance.
At first sight they appear to be rival explanations of the same phenomenon but they are not: explanation building shows that both hypotheses can be applicable at the same time. This is because respondents that indicated different perceived complexities as a positive phenomenon still mentioned negative consequences of these differences.
There was also a third group of respondents that indicated that different perceived complexities did not influence project performance in any way. They were labelled as a rival respondent towards both hypotheses at the same time.

> **"Different perceived complexities are the realities of the project„**
>
> *Interviewee — PDO member*

The number of respondents contributing to hypothesis VI, VII or rivalling VI and VII are shown in chart 6.7.

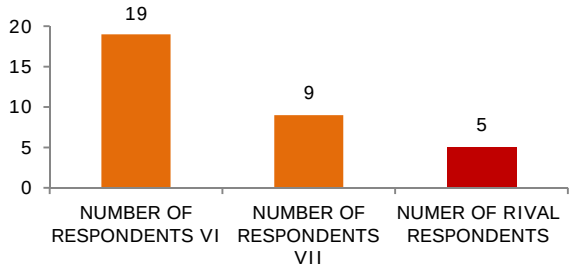


CHART 6.7 NUMBER OF RESPONDENTS CONTRIBUTING TO HYPOTHESES VI AND VII AND THE NUMBER OF RESPONDENTS THAT RIVAL BOTH HYPOTHESISES

Confirmation of hypothesis VI was, besides in the interviews, also found in the case report of case five: different perceptions seemed to stall the progress of the project. Confirmation of hypothesis VII was found in cases four and five: different perceived complexities seemed to benefit project performance within those projects.

Because both hypotheses could be more than once confirmed at the same time within one single interview and because both hypotheses apply to different case reports, it was decided to judge both hypotheses as valid at the same time.

Both hypotheses were however challenged by five respondents (which is a substantial number). These respondents indicated that different perceived complexities had no influence on project performance. This leads to the proposition that there is a third possible impact of different perceived complexities: no impact. This will be considered in answering the research question in the conclusion.

6.2. Results of the descriptive research: interventions dealing with project complexity

Chapter four already mentioned some interventions that respondents applied to deal with project complexity. Descriptive research was used in order to locate, describe and

categorise *all* mentioned interventions dealing with project complexity. This section will present the results of this identification and the next chapter will provide a reflection on these descriptions.

The interventions were identified within the in-depth interviews. Respondents were asked how they managed their top-3 TOE-elements and were later on specifically asked how perceived complexities were managed in the project. Some respondents elaborated more on how they managed complexity than others and therefore mentioned multiple interventions dealing with complexity.
All interviews were coded on interventions and these interview-parts were interpreted by the researcher: the researcher summarised all interview paragraphs into concrete interventions.

This resulted in a list of 213 interventions dealing with project complexity which were categorised by three steps: (1) they were first sort by role, (2) then by the aimed objective of the intervention and (3) then by intervention-type. All three categorisations will be explained and justified below.

First all interventions were categorised by the role-groups as earlier presented in chapter three. This categorisation was the most logical since the perceived complexities of respondents were also primarily based on the role of the respondents (see §6.1): this makes the categorisation by role the most logical categorisation.

Second all interventions were categorised based on their aimed objective: every role mentioned interventions that were applicable within their own role (so interventions that improved the performance of themselves) or interventions that dealt with other role-groups. This means that civil principals, local stakeholders and contractors mentioned interventions that were aimed at managing the complexity between themselves and the Project Delivery Organisation. It also means that members of Project Delivery Organisations indicated interventions to deal with all these three role-groups. This is graphically visualised in figure 6.2.
The identification of the 'internal interventions' (used by civil principals, local stakeholders and contractors mentioned to manage themselves) seems to contradict with the previous statement that this research focuses itself only on a Project Delivery Organisation's perspective. It is however believed that insights into these interventions benefit the Project Delivery Organisation since they create awareness for the actions of others.
Interventions between local stakeholders, civil principals and contractors were not the main focus point of this research and are therefore not mentioned. This however does not imply that they are absent: they are just not described in this research.

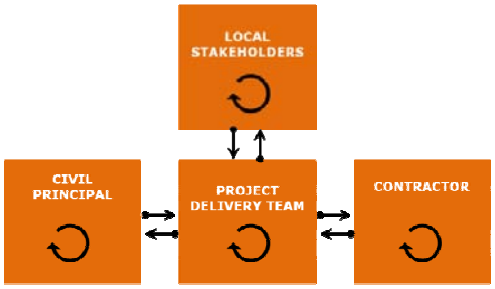


FIGURE 6.2 VISUALISATION OF THE 10 DIFFERENT CATEGORIES OF RESEARCHED INTERVENTIONS. EVERY ARROW SYMBOLISES A CATEGORY OF INTERVENTIONS

Third all interventions were categorised based on the framework constructed in chapter two. This means that all interventions were classified as *controlling*, *connecting* or *actuating* interventions.

The results are shown below. For each role-group the interventions to manage themselves are displayed followed by the interventions that dealt with the PDO. The interventions that were mentioned by the PDO to deal with the specific role-group were mentioned third. Some interventions towards other role-groups were not interventions to deal with that other role-group but advices to the other role-group on how that group *should* manage project complexity. These advices were mentioned because they were seen as a specific kind of interventions but they are clearly indicated as advice in the overviews.

It should be emphasized that this research did not formulate a threshold to test if an intervention should be mentioned in this research: every intervention was described. This means for example that an intervention that was mentioned by one respondent was equally valued to an intervention that was mentioned by ten respondents. This is due to the qualitative and descriptive nature of the assessment: the objective is to identify interventions, not to judge them.

6.2.1. *Interventions mentioned by and about civil principals*

Civil principals focussed their interventions in managing the process of decision-making (table 6.2). They mainly mentioned controlling interventions towards the PDO (table 6.3) and did not mention actuating interventions.

PDOs mentioned a noteworthy amount of actuating interventions towards civil principals (table 6.4) which are meant to influence the process of decision-making. They emphasized the importance of clear and swift decision-making so that PDOs could focus on the execution of the project.

TABLE 6.2 INTERVENTIONS DEALING WITH COMPLEXITY APPLICABLE TO CIVIL PRINCIPALS MENTIONED BY CIVIL PRINCIPALS

Type	Mentioned interventions
Controlling interventions	Always keep talking to other civil principals Separate the task to defend an interest from the task to lead to process of decision-making Prepare decisions on lower organisational-levels before the actual decision between organisations is taken Create time by disconnecting critical project components from the project in the tender
Connecting interventions	Surround yourself with people that think different from yourself Involve all important stakeholders in decision-making Be open and transparent towards others Create awareness of the project and its problems within the own organisation Steer on understanding other people's realities Communicate often with interfacing projects
Actuating interventions	Put pressure on decision-making by enabling superiors Apply either a lead-and-follow-approach or a consensus-approach to enforce decision-making Create ownership of the project by creating an ownership-consultation

TABLE 6.3 INTERVENTIONS DEALING WITH COMPLEXITY APPLICABLE TO THE PROJECT DELIVERY ORGANISATION MENTIONED BY CIVIL PRINCIPALS

Type	Mentioned interventions
Controlling interventions	Make use of independent experts to assess the judgements of PDOs Organise the PDO in an independent project bureau Create an internal body within the PDO that checks the PDO Coach the PDO with the help of independent coaches Replace people within the PDO if they block progress Carefully judge the design alternatives of the PDO
Connecting interventions	Create a workspace where people from the civil principals and the PDO can physically interact with each other Do not involve more people when project performance is poor: they increase complexity Ask open questions towards the PDO and ask the questions behind questions Create trust with the PDO by attending informal meeting and organising activities between civil principals and the PDO Make use of interpreters to transfer messages correctly to the PDO
Actuating interventions	-

TABLE 6.4 INTERVENTIONS DEALING WITH COMPLEXITY APPLICABLE TO CIVIL PRINCIPALS MENTIONED BY PROJECT DELIVERY ORGANISATIONS

Type	Mentioned interventions
Controlling interventions	Manage civil principals by explaining the complexity of the project in a clear story Make detailed designs as early as possible in the process Advice. Organise the PDO in an independent project bureau Advice. Provide enough budget and time in order to reduce project complexity Advice. Civil principals need to make decisions on time and with enough available budget so that the environment can be approached transparent and open by the PDOs
Connecting interventions	Create trust and awareness with all important civil principals Create a tool that supports the story when explaining project complexity to civil principals
Actuating interventions	Build an unofficial intern network to enforce or influence decision-making Explain others' perceived complexities within the own organisation Initiate concrete solutions to support decision-making between civil principals Make strong statements to enforce decision-making Let sponsors co-sign important decisions to create awareness Escalate problems to superiors so that they can enforce decision-making at civil principals

6.2.2. *Interventions mentioned by and about contractors*

Contractors mentioned a large number of controlling interventions to deal with project complexity (table 6.5) and did not mention one single connecting intervention. There were some general remarks that old-fashioned contracting resulted in delivering a project but that more modern contracting focuses on delivering a service: the traditional approach however caused a lot of damage to the image of contractors and still needs to be repaired.
Towards the PDO the contractors mentioned however primarily connecting interventions (table 6.6). Controlling interventions were all formulated as an advice, which indicates that contractors believed that PDOs must take controlling measures in order to make a connection with contractors possible.
PDOs mentioned on their turn a large number of controlling interventions to deal with the contractor (table 6.7). They primarily indicated that contractors had to do more than just 'building': they also had to conduct environmental communication and had to show responsibility for delivering an integral design.

> **"It is a great mistake to make the contractor responsible for everything: this privatises the neighbours' quarrel but its consequences will eventually catch up double with public authorities„**
>
> *Interviewee — local stakeholder*

TABLE 6.5 INTERVENTIONS DEALING WITH COMPLEXITY APPLICABLE TO CONTRACTORS MENTIONED BY CONTRACTORS

Type	Mentioned interventions
Controlling interventions	Environmental managers need to claim space within PDOs of contractors Organise interface meetings and apply systems engineering to bring decisions into action Replace people if they do not accept the project management approach Find adequate people within scientific institutes and pensioned engineers Stress the collaboration between sub-contractors Combine the DB and MO organisation within one organisation (applicable to DBFM(O) contracts) Manage the relations between disciplines Create time by conducting processes parallel instead of sequential Use systems engineering to execute large contracts Manage expectations of project employees by communicating clearly about deadlines
Connecting interventions	-
Actuating interventions	Some people must defend the interests of third parties within the own organisation

TABLE 6.6 INTERVENTIONS DEALING WITH COMPLEXITY APPLICABLE TO THE PROJECT DELIVERY ORGANISATION MENTIONED BY CONTRACTORS

Type	Mentioned interventions
Controlling interventions	Advice. The PDO needs to mirror its organisation to the contractor so that the counterparts between both organisations become clear Advice. The PDO needs to ensure that the right and complete information is provided Advice. The PDO needs to take responsibility for certain project tasks (e.g. environmental communication) instead of transferring them to the contractors
Connecting interventions	Settle differences with the help of independent third parties Separate conflicts from the process by reaching 'agree to disagree' Communicate transparent and honest: create trust Exchange interests between both parties Create a workspace where people from the contractor and the PDO can physically interact with each other Arrange a PSU in which both parties participate and exchange visions. Organise frequent follow-ups Design a clear consultation structure which makes clear who needs to talk about what to whom Create continuity in staffing to ensure a long collaboration between the same people Organise 1-on-1 meetings between counterparts of the contractor and the PDO Advice. PDOs need to make the first move in creating trust and a good collaboration
Actuating interventions	People must focus on project interests instead of company interests while collaborating People must think win-win during collaboration, not lose-win or win-lose

TABLE 6.7 INTERVENTIONS DEALING WITH COMPLEXITY APPLICABLE TO CONTRACTORS MENTIONED BY PROJECT DELIVERY ORGANISATIONS

Type	Mentioned interventions
Controlling interventions	Fix the remuneration in the tendering phase to focus the tenders on quality Control communication of other PDO members during the dialogue phase in order to prevent a juridical falsification of the dialogues Create a clear and unambiguous design core which functions as layer for conversations Choose the appropriate contract type: integrated contracts provide less space for interactivity Formulate clear unambiguous criteria in the contract Conduct audits with the contractor to control progress (applicable to integrated contracts) Force the contractor to participate in environmental communication Force the contractor to be the integral design leader among sub-contractors PDOs must manage the expectations of contractors Ask detailed designs during the dialogue phase to ensure a qualitative design Be willing to end the contract if a contractor fails to for fill its duties
Connecting interventions	Organise interface meetings Create a good atmosphere during the dialogue phase: this forms a foundation for future collaboration Create a workspace where people from the contractor and the PDO can physically interact with each other Create continuity in staffing to ensure a long collaboration between the same people Show a vulnerable attitude towards the contractor and endure this attitude longer than comfortable Arrange a PSU in which both parties participate and exchange visions. Organise frequent follow-ups Handle complexity together as a team, do not fight each other
Actuating interventions	Enable authorities to empower legislation towards contractors Use the contractor to negotiate with local authorities on permits Public parties need to stay involved in the project to defend the public interest (applicable to D&C and DBFMO contracts) Escalate decisions to superiors if contractors and PDO cannot come to a decision

6.2.3. *Interventions mentioned by and about local stakeholders*

Local stakeholders mentioned a noteworthy low number of interventions which they applied to themselves (table 6.8) but did mentioned a large number of advices towards the Project Delivery Organisation (table 6.9): these advices also contained, besides connecting interventions, controlling interventions that functioned as pre-condition to establish a collaboration between PDOs and local stakeholders.

PDOs in their turn mentioned a lot of interventions to deal with external stakeholders (table 6.10); approximately half of these interventions were intended to control local stakeholders. Local stakeholders advised however connecting interventions as the best suited intervention-type towards local stakeholders.

> **"You should not just send and receive messages: you have to actively look for questions in the projects' environment„**
>
> *Interviewee — PDO member*

TABLE 6.8 INTERVENTIONS DEALING WITH COMPLEXITY APPLICABLE TO LOCAL STAKEHOLDERS MENTIONED BY LOCAL STAKEHOLDERS

Type	Mentioned interventions
Controlling interventions	Focus attention to the own circle of influence
Connecting interventions	Keep conversations going with the PDO Advice. Create a workspace where local stakeholders and the PDO can physically interact with each other
Actuating interventions	Explain the perceived complexities of others within the own organisation Be prepared to operate between the rules and protocols to ensure progress Use perceived complexities as a strategic tool to influence decision-making

TABLE 6.9 INTERVENTIONS DEALING WITH COMPLEXITY APPLICABLE TO PROJECT DELIVERY ORGANISATIONS MENTIONED BY LOCAL STAKEHOLDERS

Type	Mentioned interventions
Controlling interventions	Explain your complexity with the support of photos and pictures Advice. Provide all stakeholders with all information Advice. Do not make the PDO responsible for defending the interests of the environment but an independent party: this prevents conflicts of interests Advice. Centralise the results towards the environment in the project: mind about working hours Advice. Turn the responsibility for the burden of proof when it comes to damage: the PDO must show that they are not responsible for damage Advice. Manage expectations by communicating clear about the available budget for the project Advice. Replace people within the PDO if they are not capable in connecting to the environment Advice. PDOs need to stay involved in environmental communication and not shift all responsibilities to the contractor Advice. Create enough budget to manage the complexity within the project Advice. Make the compensation desk equally important to the project bureau
Connecting interventions	Listen carefully to each other and show empathy for other perceived complexities Communicate different experiences and create thereby trust without mitigating arguments Prepare formal meetings between the PDO and the environment in informal meetings Create space to obey interests of others Kindness is important in the interaction with other people Advice. Build goodwill in the environment: this functions as castor oil in the project Advice. Involve the environment early in the process Advice. Show construction decency in order to strengthen the relation between project and the environment Advice. Make sure that the employees of the contractor have fun in their work Advice. Make civil principals aware of the risks and conditions of projects an grow awareness on the option to not execute a project
Actuating interventions	Enforce participation with the help of juridical processes Build an internal network within the organisation of the PDO to influence decision-making: focus on the experts that can strengthen your own arguments

TABLE 6.10 INTERVENTIONS DEALING WITH COMPLEXITY APPLICABLE TO LOCAL STAKEHOLDERS MENTIONED BY PROJECT DELIVERY ORGANISATIONS

Type	Mentioned interventions
Controlling interventions	Separate the task to defend an interest from the task to lead to process of decision-making Manage expectations of the environment by preparing and motivating decisions carefully Translate the most important environmental demands into contractual criteria (applicable to D&C contracts) Manage expectations on damage compensation Communicate important issues and the way they are handled directly to the environment. Create confidence by applying actions based on knowledge Make a clean assessment of all environmental interests Do not adept the environmental strategy to information evenings; the present individuals are usually not representative for the entire environment
Connecting interventions	The interests of environment must be at the same level as interests of the construction Involve the environment as early as possible in the process Steer on understanding, not on consensus: seek interaction without informing the environment Show a vulnerable attitude towards the environment by admitting the facts you do not know and communicate transparent Do not tell your own story but listen: perceptions are the reality Connect the workmen with the environment to enhance understanding Conduct Joint Fact Finding together with the environment: independent third parties, selected by the environment and paid by the project, investigate certain project parts Design a clear consultation structure with the environment: a combination between 1-on-1 meetings, round table meetings and information evenings
Actuating interventions	Build an unofficial intern network to enforce or influence decision-making at local stakeholders Involve the environment to co-design Escalate problems to powerful superiors in order to enforce decision-making at local stakeholders

6.2.4. *Interventions mentioned by PDOs about PDOs*

The final group of interventions were the interventions mentioned by PDO-members and applicable to PDOs.

PDO-members mentioned a balance between controlling and connecting interventions (table 6.11). They furthermore emphasized that the right people made the difference and that project management was a combination of 'soft' and 'hard' management techniques.
One interesting remark made by several respondents is that the interests of the project should be centralized within project management, not the interests of the individual companies contributing to the PDO or other companies.

TABLE 6.11 INTERVENTIONS DEALING WITH COMPLEXITY APPLICABLE TO PROJECT DELIVERY ORGANISATIONS MENTIONED BY PROJECT DELIVERY ORGANISATIONS

Type	Mentioned interventions
Controlling interventions	Replace PDO-members if there is too much alignment within the PDO Create a clear PDO with dedicated employees Do not focus the PM approach on planning, scope and budget: they are expressions of problems, not sources Steer on unambiguous views by providing all PDO-members with the same information Keep in close contact with line-management to prevent staffing problems Create redundancy by pointing out assistants for each role in the PDO Involve market parties if the available in-house knowledge proves to be inadequate Content experts must claim enough space with overall project management to execute their jobs Create time by executing project parts parallel instead of sequential De-bundle, de-phase and decompose if a project is getting too complex Apply an integral approach towards the assignment
Connecting interventions	Focus on perceptions of PDO-members to create learning-loops Do not focus on tools in the PM approach: focus on people and their skills Cultivate a culture by showing example behaviour and centring values Create a workspace where PDO-members can physically interact with each other Listen to what is meant, not to what is said. Ask the questions behind questions: these questions need to be open and answers need to be provided with examples Explain your own perceived complexity clearly to others Create understanding for the contribution of one role in the bigger picture Select the right people: they must have fun, be ambitious, happy, trustful, valiant and transparent Staff the right people in the right phase of the project: different phased require different type of people Use experts on detailed topics to understand the project Focus management on the relations between disciplines
Actuating interventions	Project managers must stimulate other PDO-members to discover the project on their own Create the right knowledge and information necessary for PDO-members to do their jobs Escalate problems to powerful superiors in order to enforce PDO-members to listen

6.2.5. *Perception-based management*

Respondents mentioned a large number of interventions that were related to management of different perceived complexities: these interventions were all categorised as *connecting interventions*.

Respondents were specifically asked for interventions dealing with different perceived complexities: this explains the large number of mentioned interventions on this topic. The respondents were however also asked how important these interventions were within the total picture of project management: a large majority answered that the management of different perceived complexities was very important. This indicates that these interventions were not only mentioned because they were asked for but also because they were considered as important interventions.

This embeds perception-based management in the total project management of LCPs. The same contradiction as found in the hypothesis earlier can however also be found within mentioned interventions: respondents mentioned interventions that prevented perceived complexities from becoming a problem and they mentioned interventions that used perceived complexities to improve project performance.

Chapter seven will further elaborate on perception-based management and the managerial consequences. The term perception-based management refers to the control and use of perceived complexities within LCPs: this term will be used from now on throughout the remainders of this thesis.

6.3. Interventions and perceived complexities

Chapter five showed that it was plausible that perceived complexities were related to interventions dealing with complexity thereby stating the proposition that a perceived complexity of an individual influences the interventions that the individual applies to deal with complexity.

The perceived complexities of respondents were categorised according to the earlier formulated four types of perceptions, showed in chapter five (figure 5.28). The question now is if these four types of perceived complexities lead to different interventions dealing with complexity.

All respondents were therefore classified within the four types of possible perceived complexities. The ratio of controlling, connecting and actuating interventions for each

perception-type was then determined and the results are shown in chart 6.8. Since only one respondent was identified with the second type perceived complexity ('challenge without influence') this perception-type was not based as valid enough to compare it with the other three types.

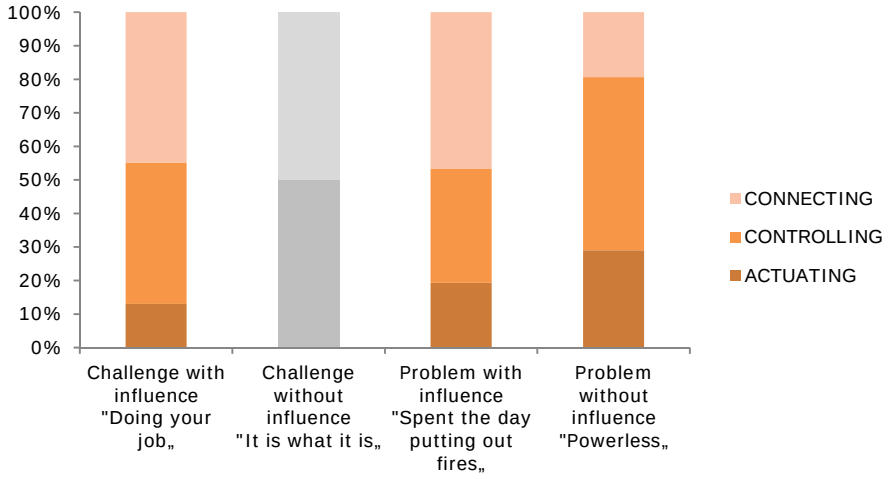


CHART 6.8 THE RATIO OF CONNECTING, CONTROLLING AND ACTUATING INTERVENTIONS FOR EACH TYPE OF PERCEIVED COMPLEXITY (n=30). ONLY ONE RESPONDENT WAS LABELLED AS TYPE-II ("IT IS WHAT IT IS") AND THEREFORE THIS OUTCOME WAS NOT CONSIDERED VALID FOR THIS RESEARCH.

Chart 6.8 shows that the balance between connecting, controlling and actuating interventions is relatively similar within the first and third type of perceived complexities. The fourth however shows a much greater share of actuating and controlling interventions compared to the first three types of perceived complexities.

So respondents that based their perceived complexity on a low level of influence and perceived complexity as a problem indicated much more controlling and actuating interventions then others. This might indicate that the more someone feels in control, the more connecting interventions are used. Or it might indicate that the more connecting interventions are used, the more someone feels in control. This research does not provide enough data to exclude one of these two options.

6.4. Conclusion

This chapter showed the results of the data analysis, consisting of explanation building and descriptive research. The explanation building led to several hypotheses which were used to answer the research questions formulated in the introduction of this chapter. The descriptive research provided insights into the management of project complexity in practice and the connection between different perceived complexities and interventions.

6.4.1. *How do the different perceived complexities originate?*

The lens model in chapter four described perceived complexities: it thereby showed that the construction of a perceived complexity takes place by *selecting* and *judging* cues from the real world. It also showed that the TOE-elements could be seen as these cues but it did not answer the question *why* practitioners select specific TOE-elements and *why* they judged them the way they did.

This chapter showed that the *selection* of TOE-elements as cues is influenced by at least three separate drivers: (1) the impact of an element on the project and the control the practitioner has on this element; (2) the contextual variables of the project and (3) the experience of the practitioner.
The second driver (the contextual variables) was however contradicted by several respondents. These rivalling explanations need to be researched in chapter seven.
The proposition that education is a driver behind selection of cues was rejected.

This chapter also showed that the *judgement* on the TOE-elements is driven by at least one driver: the interest that the practitioner represents in a project. This interest is based on the role of an individual and/or on the personal values of a individual.

This driver was also contradicted by several respondents and therefore also needs discussion in chapter seven.

Differences in perceived complexities of practitioners can be logically explained with these four different sources: differences in perceived complexities within the same project originate in different levels of control on elements, different levels of experience and different represented interests. Differences in perceived complexities between different projects originate from different contextual variables of projects.

Differences in perceived complexities also originate in the different levels of factual knowledge of practitioners.

6.4.2. *How do perceived complexities affect interventions dealing with complexity?*
Paragraph 6.3 showed that respondents who perceived complexity as a problem without influence ("powerless") on it tend to indicate a considerably higher ratio of controlling and actuating interventions than other respondents.

The data however does not provide enough evidence to state that the perceived complexity is the cause of this high ratio: it could also be the case that the use of connecting interventions influenced the perceived complexities of the other respondents.
It is however also clear that mentioned interventions defer between role-groups and that perceived complexities are mainly based on roles of individuals (chapter five): this connection makes it feasible that interventions and perceived complexities have some kind of connection.

It is therefore concluded that there is indeed a relation between perceived complexities and the type of used interventions dealing with project complexity. The specifics of this relation can however not be determined within the available data-set and is a topic for further research.

6.4.3. *What are the implications of different perceived complexities on project performance?*
The data analysis showed four different ways of handling perceived complexities: the way of handling determined the impact on project performance and therefore these four ways of handling need to be explained together with their impact on project performance.

The way of handling perceived complexities is determined by three parameters which together typify the way of handling. These parameters are the level of awareness, the acceptance of differences and the judgement on these differences. All three parameters will be explained below.

The first parameter is *awareness* which indicates whether people are aware of different perceived complexities. Without awareness there is no possibility to handle different perceived complexities: awareness is an important precondition for perception based-management.
This research did not encounter projects which were totally unaware of perceived complexities, which is not strange: all projects already participated in the first round of research which confronted a large part of the respondents with differences prior to this research.
The fourth case however showed what the consequences of unawareness could be: this case did not paid attention to different perceived complexities in the past and the respondents of this case indicated that this had led to (very) poor project performance.

The second parameter is the level of *acceptance* which indicates if different perceived complexities are accepted or rejected. Rejection indicates that the efforts will focus on one single perceived complexity for all actors and stakeholders within the project: it means that differences are eliminated and one single perception is strived for. Acceptance means that different perceived complexities are accepted and that there is no effort whatsoever to alter or eliminate perceived complexities.
Very little respondents indicated that they reject perceived complexities and strive for a single definition but it was mentioned by enough respondents to consider it as a valid parameter.

The third parameter is the *judgement* on these differences which indicates how the different perceived complexities are used within the project. The different kinds of judgements are

reflected within hypothesis VI and VII: perceived complexities can be *used* to improve project performance or perceived complexities must be *controlled* in order to prevent poor project performance.
These two statements may look mutually exclusive but they are however not: respondents that mentioned positive effects of different perceived complexities also indicated negative consequences of these differences.
This led to the theory that both statements are part of the same process: at first, different perceived complexities need to be controlled by creating a common understanding between the practitioners (hypothesis VI) and then they can be used in order to improve the projects' performance (hypothesis VII).
The case reports (chapter five) showed this as well: cases three and four were both cases that were judged as performing well and they were also the only two cases who thought of different perceived complexities as a chance to improve project performance. This is a strong indication for a causal connection between the judgement on perceived complexities and projects' performance.

These three parameters lead in the opinion of the author to the four ways of handling different perceived complexities: they can be ignored, they can be eliminated, they can be controlled and they can be exploited. The case reports led to the proposition that these actions are steps in improving project performance: *ignorance* leads to least improved performance, followed by *elimination*, then by *control* and finally *exploitation* leads to the most improved performance. These different handlings and their relation are shown in figure 6.3.

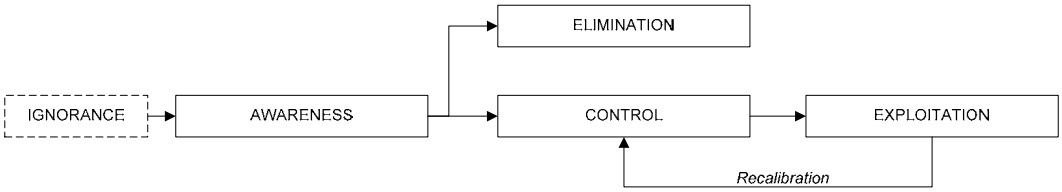
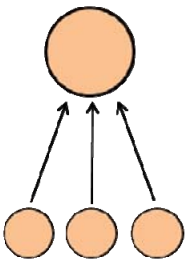
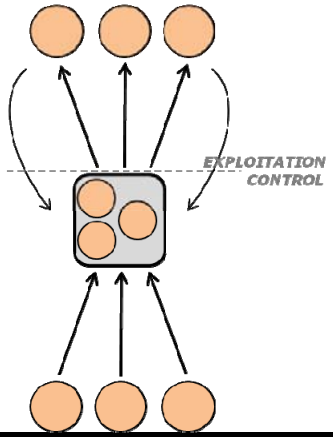


FIGURE 6.3 DIFFERENT WAYS OF HANDLING DIFFERENT PERCEIVED COMPLEXITIES

The arrow flowing back from exploitation to control refers to the recalibration of the common understanding. This will be further elaborated in chapter seven.

Awareness is seen as a pre-condition for the other three ways of handling differences. The remaining three ways of handling are actually two ways of handling: exploitation is seen as the next step after control. This leaves two different management approaches towards perceived complexities when awareness is assumed as pre-condition. These two approaches are graphically shown in table 6.4. The figure on the left shows the elimination of perceived complexities, the figure on the right shows the control and exploitation of these differences. The right figure is split into an A and a B part: the A part refers to the view that perceived complexities need to be controlled to prevent problems; the B part that perceived complexities can to be exploited to improve project performance.

TABLE 6.12 MODELS OF THE TWO DIFFERENT MANAGEMENT APPROACHES TOWARDS DIFFERENT PERCEIVED COMPLEXITIES ONCE AWARENESS IS CREATED

Performance & model	Elimination	Control/Exploitation
Indication of project performance	+	++/+++
Corresponding model		

Chapter seven will elaborate on the impact of these models on the management of project complex within projects.

7. Results & discussion

Chapter six showed that two management approaches towards perceived complexities and four ways of handling them were extracted from the data. It designed a model used to indicate how different perceived complexities could be managed within LCPs.
These outcomes were internally validated with the project managers and externally validated in an expert meeting with approximately 30 construction practitioners. The outcomes were also reflected in literature. This chapter will describe the results of this validation.

The following sub-research question will be answered in this chapter:

- What do different perceived complexities mean for project management? *(sub-question G)*

The first section will reflect on the mentioned interventions to deal with project complexity and will argue perception-based management as an important method to deal with project complexity (§7.1). The second part will discuss the implications of different perceived complexities on project performance and the concept of perception-based management (§7.2). This discussion is followed by the managerial implications of this research (§7.3). The chapter ends with the indication of the limitations of this research (§7.4).

7.1. Dealing with project complexity

The descriptive research showed distinct differences between the different role-groups in mentioned interventions. This section reflects on these described interventions with the help of literature.

The mentioned interventions by PDOs show a balance between controlling and connecting/actuating interventions which was also found within the literature described in chapter two: management of project complexity consists of the control-approach combined with the hands-off-approach. Other role-groups show however a different balance in mentioned interventions. The following section will reflect on the interventions between the PDOs and the other role groups.

The first notable group of interventions that is treated are the interventions between civil principals and PDOs. These interventions show that civil principals tend to focus on the process of decision-making and the control of the PDOs. PDOs on the other hand focus primarily on actuating interventions when they deal with civil principals.

This focus on decision-making has everything to do with the problems in making those decisions: there are often many civil principals that need to reach agreement on the assignment that is handed over to a PDO. These civil principals often have contradicting interests and therefore decision-making appears to be quite difficult. The role of funding agencies (providing grants) seems to be especially peculiar: they can be the sponsor of the project without taking responsibility for it.
These many civil principals that do not claim ownership of projects can lead to poor decision-making: the assignment is not clear enough, does not provide the necessary budget and/or does not provide enough available time to execute the project in an ordered way.

> **"The role of funding agencies within the process of decision making is very figurative: it is a risk-adverse role and funding is only awarded after tendering„**
>
> *Interviewee — PDO member*

The process of decision-making can lead to poor performance and civil principals respond to this by applying more controlling interventions towards the PDOs.
But PDOs desire exactly the opposite: they want more 'freedom' to execute the project and therefore try to steer on an unambiguous and clear assignment with sufficient available budget. This explains the high number of actuating interventions from PDOs towards civil principals.
PDOs also indicate that the controlling interventions of the civil principals work adverse since they increase project complexity: PDOs have to dedicate more time to the response on the controlling interventions of the project principals. This leads to less dedicated time in actually managing the execution of the project.

This explanation is justified with the following data:

- The poor performance in case one was ascribed by respondents to the lack of decision making between several civil principals.
- The mandate given to the project managers of cases three and four was seen as a pre-condition for the good project performance within these cases (as validated with these project managers).
- The uncertainty in the scope of case five was caused by the interventions of the civil principal.
- Several respondents indicated that establishing a project bureau would lead to better project performance since it creates freedom for the PDO.

This theory is strengthened by the theory of Winch (2013). He researched the causes of escalations in major projects and concluded that the majority of the causes lay within the process of decision-making and the commitment to wrong decisions (figure 7.1).
The statements about the project sponsor are also confirmed by Favari (2012) who indicates that the sponsor of a project needs to be known so that they can be held responsible for the performance of the project.

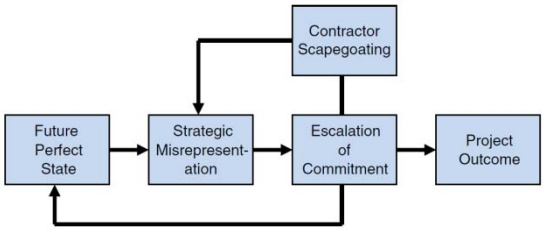


FIGURE 7.1 ANALYTICAL MODEL OF PROJECT ESCALATION. FROM: Winch (2013)

Contractors mention primarily controlling interventions to deal complexity and mention much more controlling interventions than PDOs. This connects to the theory of Davies and Mackenzie (2013): the contractor is responsible for a system within a system and these systems need a controlling management approach. The PDOs focus themselves on the bigger picture and act therefore more on the level of meta-systems: these systems require a more hands-off approach.
It is however contradicting that contractors mention their new role as service-provider but do not mention connecting interventions: part of this service is supposed to be the interconnection with the environment of the project.

> **"It is not natural for contractors to think from a users' perspective„**
>
> *Interviewee - contractor*

Local stakeholders did mention very little interventions that they could apply themselves but did indicate that PDOs should apply a connecting approach towards local stakeholders. PDOs seem to apply this approach sparsely: they often still approach the environment with the intention to manage stakeholders instead of connecting to them.

The several role-groups also mentioned overlapping interventions to deal with project complexity. These interventions seem to be independent of the role and can be seen as overall interventions that deal with project complexity:

- *Interact physically*. Several respondents mentioned the importance of physical contact rather than communication by telephone or computer. A workspace where multiple parties are present (e.g. an office space) is preferred.

> "Being close to each other works. 100 meters of separation can already be too much distance since you then have to use a telephone„
>
> *Interviewee — Civil principal*

- *Separate roles*. Organisations must represent one interest: this ensures that every interest is equally accounted for in the process. People defending an interest may not be the same people that lead a conversation or process.
- *Build networks*. Building and maintaining networks within the own organisation or within other organisations was mentioned as crucial in order to be able to act between rules and protocols.
- *Find adequate people*. A large number of respondents indicated that the involved people make the difference in LCPs.

> "20% of the people pull the trailer, 70% stands on it and 10% walks behind it. You have to be prepared to fire those last 10%„
>
> *Interviewee - Contractor*

- *Apply perception-based management*. The exchange of different perceived complexities was mentioned as an important management tool in LCPs. The next paragraph (7.2) will elaborate further on perception-based management.

It is therefore overall concluded that the balance described by literature between controlling and connecting interventions was indeed found but greatly depends on the role-group.

Another notable observation was made within the found interventions: there seems to be a cross application between controlling and connecting interventions. Connecting interventions were sometimes used to gain control over the project and controlling interventions were used to make connecting interventions possible.
Examples of controlling interventions making connecting interventions possible are the actuating interventions applied by PDOs towards civil principals: by demanding a clear assignment that leaves enough time and provides enough budget to execute the project the connecting interventions towards the local stakeholders and contractors become possible. These interventions often cost time and money and therefore this controlling approach is necessary to enable the hands-off approach.
An example of a connecting intervention used to gain control has already been mentioned in the previous chapter: the management of perceived complexities is necessary to prevent them from becoming a problem in the project which means that this management aims to gain control on the project.

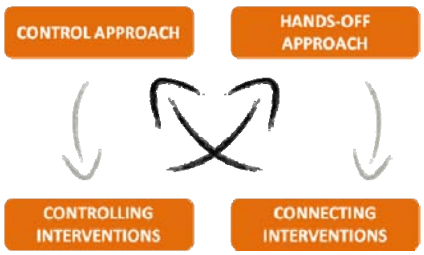


FIGURE 7.2 CROSS-APPLICATION OF CONTROL AND HANDS-OFF APPROACH: CONTROLLING AND CONNECTING INTERVENTIOS MAKING THE OTHER APPROACH POSSIBLE

This cross application is graphically visualized in figure 7.2 and seems to be complementing the available literature: this literature (Thomas & Mengel, 2008; Hertogh & Westerveld, 2010; Koppenjan, *et al.*, 2011; Davies & Mackenzie, 2013) acknowledges that a combined approach is necessary to manage project complexity within LCPs but does not mention the cross-application of the two types of approaches.

During the internal validation with the project managers this cross-application was also partly mentioned: the management of detailed complexity was in some occasions considered to be a precondition to enable the management of dynamic complexity.

7.2. Perceived complexities and perception-based management

This section will elaborate on the critical remarks made in chapter six, reflect on the two models that were used to indicate ways of handling different perceived complexities and will conclude with an assessment of interventions used to apply perception-based management.

7.2.1. *Determining the origins of perceived complexities*

Chapter six mentioned two critical remarks on the theory about sources of perceived complexities: it was questioned whether the contextual variables indeed played a role in establishing a perceived complexity and whether the interests of respondents really determined a perceived complexity.

Contextual variables were found as a source for perceived complexities but this source was partly contradicted by the answers given on the control-question. This question asked if the top-3 TOE-elements were project-specific: the expected answer would be 'yes' (because contextual variables differ within each project). A majority of the respondents however answered 'no'.
This could be explained with the help of hypothesis II ('the selection of the TOE-elements is influenced by experience of individuals'): experience seems to sometimes prevail over contextual variables as contributor to the perceived complexity. Many respondents indicated that they would not change their top-3 TOE-elements because they had seen these elements in projects they had conducted in the past.
So, does this reject contextual variables as a source of perceived complexities? Davies and Mackenzie (2013, p. 14) found in their research that "*a number of contextual variables shaped the programme and added to its complexity*". This theory strengthens the conclusion that contextual variables do contribute to project complexity and therefore automatically could contribute to perceived complexities. Besides, this contribution of contextual variables was not fully rejected within the available data.
It is therefore concluded that both contextual variables and experience contribute to a perceived complexity but they are not necessarily juxtaposed: experience sometimes seems a more important determiner of a perceived complexity than the contextual variables.

The second critical remark applied to the *interests* as the source of perceived complexities: again a control question partly falsified this hypothesis. A minority of the respondents that were believed to have a role-based-interest did indicate that they would *not* change their top-3 TOE-elements if they would have had another role within the project. The opposite would however be expected if role-based-interests indeed contributed to a perceived complexity.
It proved to be more difficult to explain this contradiction. Table 7.1 sums up the different reasons why respondents have answered 'no' to the control question.

TABLE 7.1 MENTIONED REASONS WHY TOP-3 LISTS WERE NOT BASED ON THE ROLE OF RESPONDENTS

Respondent	Elucidation
Respondent 1	*- No elucidation given -*
Respondent 4	*- No elucidation given -*
Respondent 5	*- No elucidation given -*
Respondent 14	The mentioned top-3 TOE-elements were crucial for the project and would affect all parties if they would went wrong
Respondent 15	The mentioned top-3 TOE-elements were general for all LCPs
Respondent 17	*- No elucidation given -*
Respondent 18	The mentioned top-3 TOE-elements were general for the project
Respondent 21	*- No elucidation given -*
Respondent 26	The top-3 TOE-elements were also seen within other projects
Respondent 27	The mentioned top-3 TOE-elements were general for the project
Respondent 30	*- No elucidation given -*

Little elucidations were given but the few that were given indicate that these respondents dedicated their perceived complexity to either *experience* or *impact on the project*, which correlate with hypothesis II and I. So the control-question does not directly reject the *interests* of a practitioner as source but it sometimes seems to be a less dominant contributor to perceived complexities then the *experience* of the respondent and the *impact of the component on project complexity*. It must however be emphasized that the available data to support this conclusion is very limited.

It is overall concluded that hypothesis I, II, III and IV are all valid hypotheses in explaining the origins of perceived complexities. However, it seems that there is a hierarchy in order: experience and impact & control appear to be more determinative than the contextual variables and interests of respondents.
This hierarchy does however not seem to be applicable to all respondents, which leads to the conclusion that all four hypotheses are valid contributors to a perceived complexity but the degree of contribution can vary for each individual.

7.2.2. *Contributions of perception-based management to project performance*

The previous chapter presented two encountered models to deal with project complexity: steering on unanimity and steering on ambiguity.

The first model does acknowledge different perceived complexities and tries to unify these different perceptions into one unanimous perceived complexity. This model assumes that perceived complexities can be altered, but is this assumption legit to make?
This research showed that a perceived complexity is partly based on the impact of project complexity and influence on that complexity. It also showed that differences occur due to different levels of knowledge of individuals. These are all components which indeed can be altered if they are managed.
This research however showed that perceived complexities also originate in the experience, contextual variables, interests, roles and personal values of individuals. These are components which cannot be altered by project management.
The model that steers to unanimity is therefore controversial since it assumes that unanimity can be reached while this research showed that this cannot be the case due to the partly unalterable sources of perceived complexities.

Both models were discussed during the expert meeting and the construction practitioners agreed on the validity of the model that does not (try to) alter perceived complexities. They however also did not fully reject the model which steers on a single perceived complexity: practice rather uses a combination of both models.
It appeared that different situations require different models. If for example an actor has the formal right to make a decision, it can decide to take different perceived complexities into account and to use them (the 'right' model) but under the pressure of unilateral decision-making (the 'left' model).

When practitioners however had to choose between the two models during the expert meeting they nearly all chose the model which uses perceived complexities unanimous. This research will therefore elaborate on the use of that model.

This model first brings different perceived complexities together in a *mental model* without altering or modifying the different perceived complexities (the term mental model will be explained later on but can for now be seen as a jointly formulated objective of the project). This mental model is then used to diverge from and to use the different perceived complexities. In this way the approach assumes positive effects of different perceived complexities on project performance.
If the mental model is however not present, the different perceived complexities seem to influence project performance in a negative way. In other words: either you manage perceived complexities and they improve project performance or you fail to manage perceived complexities and they thwart a good project performance.

Both the internal validation with the involved project managers and the expert meeting confirmed and supported this model. Practitioners added the following elaborations on the model:

- The model relates to time: every project starts at the bottom of the model and proceeds upwards as the project progresses.
- The lower part of the model, the road towards a mental model, seems to relate with project management while the upper part seems to relate with process management.
- Using (or converging) different perceived complexities refers to the *actions* of practitioners which are based on the mental model: the actions must converge but the ideas must stay equal.
- It takes a special kind of people to use this approach; practitioners must be able to handle the degree of freedom since everyone is expected to translate the mental model into actions for its own role.

The project managers indicated that the correct application of the approach led to the continuous understanding of the dynamic (i.e. changing) complexity of the project and that different actors would take each others' difficulties much more into account.

The described approach showed a remarkable resemblance with literature theories on contemporary project management: these theories indicate that learning within the project is the most important project management tool to deal with project complexity and that this learning can be conducted with the help of *project learning* and *a shared mental model*. An elaboration on these theories will be provided below.

Cicmil*, et al.* (2006) argue that project management needs to be viewed from a different viewpoint by shifting from the normative rational approach to the developmental approach. This means that project management should focus itself on the *actuality* of projects: this approach is based on 'project learning' instead of the thinking-and-rational-approach. Project management should be centred more around the question 'what is going on in the project?'.
Ahern*, et al.* (2013) clarify this by explaining that if complex projects are characterised by a lack of prior-knowledge (i.e. that all knowledge needs to be created during the project), the management of LCPs should focus on understanding and learning the project.
They use the theory of Cleden (2009) to explain this type of knowledge: there are known-knowns; known-unknowns (i.e. *risks*); unknown-knowns (i.e. *untapped knowledge*) and unknown-unknowns (i.e. *crises* or *wicked problems*). The knowledge that must be created within LCPs consists of the unknown-knowns.

This organisational learning has been described in more detail by Reyes (2012). He argues that organisations can learn just as individuals by creating a shared mental model.
Individuals and organisations use these shared mental models to coordinate their actions and to increase their own performance.

So what are *shared* mental models? A mental model indicates what individuals see as the objective of a team performance and how these objectives should be reached (Arnold & Silvester, 2005, p. 522). Arnold and Sylvester indicate three phases in forming a team: forming, functioning and finishing. During the forming-phase the shared mental model has to be made. This shared mental model structures different mental models of the team members and also formulates a *transitive memory*: this is the process where all team members find out who knows what in the team and what is known.
George and Jones (2008, p. 522) also describe the shared mental model as one of the five key principles of organisational learning. Team members must use this shared mental model to frame problems and opportunities: at the heart of this shared mental model lie a set of work values and norms.

Perception-based management is believed to be an application of organisational learning based on a shared mental model. It must thereby be emphasized that it is *an* application and certainly not the only one: the principle of the shared mental model applies to a wide variety of aspects in teamwork. Perceived complexities are only one of them. However, it is an important one.
The theory that perception-based management is necessary within LCPs seems also to be supported by Hertogh and Westerveld (2010): they mention the subjectivity within the assessment of uncertainties within LCPs and also indicate that different perceptions are 'the reality of projects'. Both issues are addressed with perception-based management.

Examples of applications for perception-based management can furthermore be found within literature. Kent and Becerik-Gerber (2010) researched the acceptance of Integrated Project Delivery (IPD) within construction practice. They found that an early definition of project goals were an important success factor for IPD: perception-based management can help in formulating this common project goal.
Osipova and Eriksson (2013) argue that control and flexibility is necessary to apply Joint Risk Management (JRM): this type of risk management focuses on risk management as the collaboration between actors rather than the individual formal process. Perception-based management can be an application of this flexible approach that makes JRM possible.

> **"We can soothe the environment because of our understanding of the complexity in the project„**
>
> *Interviewee — local stakeholder*

But is *project learning* the only contribution of perception-based management to project performance? The data shows another important effect of perception-based management within LCPs: the collaboration between parties seem to be improved significantly with the application of perception-based management.

Several respondents mentioned the improved collaboration as the major reason to apply perception-based management. Understanding other perceived complexities and the feeling that the own perceived complexity is understood led to trust, goodwill and joy in the project. These factors were all seen as important factors behind a good collaboration.
Evidence for this effect was especially found within case four: this case showed that perception-based management led to improved collaboration between the actors. The opposite was found in the first and second case, where different perceived complexities could not be expressed and led to a tensed collaboration in which people felt close to frustrated.

So the two contributions of perception-based management to the project performance are project learning and the improvement of collaboration. These two contributions relate to the earlier presented model of perception-based management: improvement of collaboration applies to the first stage which is used to control perceived complexities, project learning to the second stage which is used to exploit perceived complexities. This is visualised in figure 7.3.

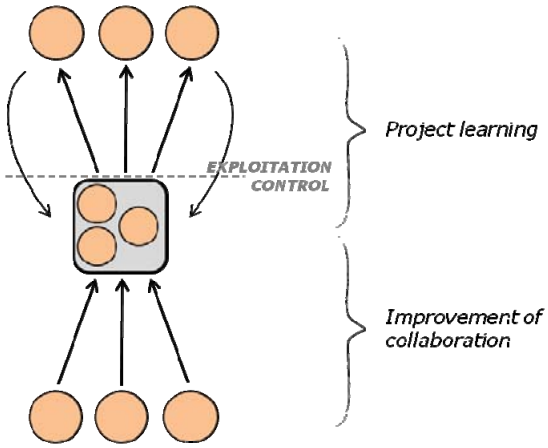


FIGURE 7.3 CONTRIBUTIONS OF PERCEPTION-BASED MANAGEMENT TO PROJECT PERFORMANCE

These two contributions were both confirmed in the expert meeting. Practitioners mentioned that different perceived complexities would become a problem if you left them unhandled. They indicated that the correct use of the model prevents problems like group thinking and a tunnel vision of a team: this relates to the process of project learning as mentioned above. Perception-based management increases the 'critical ability' of a PDO: this refers to the ability of a team to question and perform a critical review on their own delivered products.

7.2.3. *Interventions within perception-based management*

Now that it is understood where perceived complexities origin from and what their contributions are to project performance this section will argue how perception-based management can be brought into practice.
This section will be split into three parts: preconditions necessary for perception-based management, interventions that improve collaboration and interventions that improve project learning.

Preconditions necessary to apply perception-based management
Perception-based management seems to need preconditions in order to be effective. Necessary preconditions were mentioned in the interviews and in the internal validation session by project managers:

- A feeling of trust and a safe ambiance are necessary to share perceived complexities. This means that there must be tolerance to make mistakes: mistakes must be seen as a step closer to the final solution rather than failure.
- People must be able to separate facts and assumptions during conversations and must be skilled in asking questions.
- PDOs must claim the necessary space with civil principals. Perception-based management costs both time and budget and civil principals therefore often do not provide the space necessary to conduct perception-based management. Claiming this space is a rather difficult intervention according to the project managers: it seems that project managers must have a service record that results in necessary credits: only then it seems that civil principals are willing to provide space.
- The type of contract makes a difference: the alliance contract is especially classified to deal with perceived complexities of the PDO and the contractor. The D&C contract leaves little space for the exchange of perceived complexities because the contract enables the contractor to design the project according to a contract without taking into account any perceived complexity whatsoever.

Perception-based interventions that improve collaboration
Once preconditions have been established the first phase in perception-based management is the creation of a shared mental model in order to control perceived complexities and improve collaboration.

Different interventions mentioned in chapter six were grouped and this resulted in a list of interventions that improve collaboration:

- *Organise activities*. The organisation of activities in which multiple parties engage was frequently mentioned as an intervention. The project start-up (PSU) was emphasized as important activity but a number of respondents also emphasized the need for a frequent follow-up.
- *Ask questions*. A shared mental model means that individuals need to know what is known within the PDO and therefore individuals have to ask questions. Respondents emphasize the need of truly open questions that allow others to explain their perceived complexity. An open question does not assume an answer within a question (e.g. *"do you agree that...?"*) but provides space for the asked person to come with an own answer (e.g. *"what is your opinion on...?"*).
  The quest for the 'question behind the question' was also mentioned frequently and refers to the process where people truly try to found out what the counterparts' meaning of words really is: people often seem to disguise their true questions behind other formulated questions.

> **"We have learned to validate the meaning of each others' words„**
>
> *Interviewee – PDO member*

- *Explain and listen*. Although this intervention might sound trivial it was mentioned surprisingly often by the respondents. Respondents designed different tools to explain their perceived complexity which is often based on visual material supporting their story. The process of perception-based management should be focussed on understanding each others' perceived complexities rather than agreement on project complexity.
- *Use interpreters*. A couple of respondents indicated that they used interpreters in order to transfer their perceived complexity. Often these interpreters were used to overcome hierarchical barriers that prevented exchange of perceived complexities.
- *Share factual knowledge.* Chapter six showed that different levels of factual knowledge lead to different perceived complexities but this can frustrate the involved practitioners: the *known knowns* need to be exchanged transparent and open to lift all respondents to the same level of factual knowledge.

The internal validation with the project managers also brought a couple of interventions forward:

- *Share expectations*. PDO-members should exchange expectations about the final result of the project. These interventions connect to the theoretical view that a shared mental model should formulate the projects' objectives. *Value engineering* was mentioned as a tool to share these expectations.
- *Use independent parties*. Formulating a shared mental model is often difficult to do as project manager or as PDO since these practitioners often need to defend an interest themselves or are at least suspected of defending an interest. Using independent parties to formulate a shared mental model prevents this (suspicion of a) biased position. This intervention was also mentioned during the expert meeting.
- *Share beliefs and interests*. Sharing beliefs and interests rather than factual arguments were mentioned as an important intervention to approach one another. This intervention was also mentioned during the expert meeting.
  This interventions fits in the proposition that perceived complexities are based on interests but also to the iceberg model of McClelland (1973): this will be elaborated further on in this chapter.

The expert meeting also provided some useful interventions to come to a shared mental model:

- *Formulate the DNA of a project*. The shared mental model must be based on the DNA or fixed culture of a project. It is determined and renegotiated during PSUs and follow-ups but always based on this DNA: this is especially helpful when new practitioners enter the project that need to be made familiar with the project. The follow-up-activities are the appropriate moments to make newcomers familiar with the projects' DNA.
- *Accept the confusion*. Practitioners indicated that the road towards a shared mental model can be quite confusion during the early phases of the project: people have no solid point yet. This confusion is however a necessary step towards a shared mental model and also provides the space and openness necessary to come to that shared mental model.
- *Show example behaviour*. Project management needs practice what they preach: by showing example behaviour towards other team members it is believed that the shared mental model becomes possible.

Two interventions that were mentioned frequently will be elaborated further below: the interventions related to the exchange of motives and the PSU.

The interventions related to the exchange of motives have been mentioned multiple times by respondents. They reflect the importance of communication and the contents of this communication must to be based on beliefs and interests of individuals. This is validated with the iceberg model of McClelland (1973) (figure 7.4) that argues that the visible part of human motives (being knowledge and skills) forms only 20% of the total motives of an individual. The remaining 80% consists of social role, self-image, traits and motives which cannot be seen on the surface but are much more determent in constructing motives of individuals: attention should be focussed on these non-visible motives.

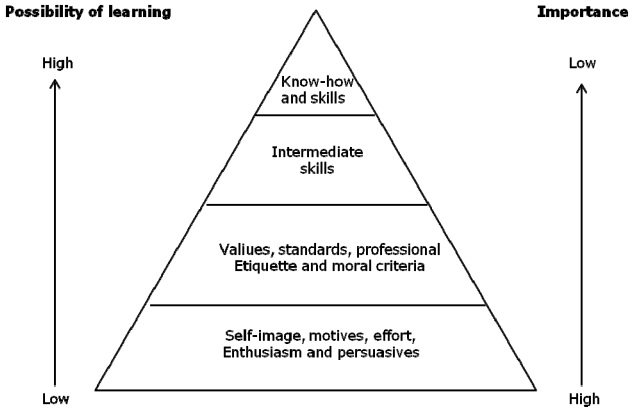


FIGURE 7.4 THE ICEBERG MODEL OF McCLELLAND (1973). FROM: EMERALDINSIGHT.COM

The second frequently mentioned intervention was the PSU. The PSU has been mentioned as important activity to exchange perceived complexities and is validated by the research of Bosch-Rekveldt (2011) who indicates that front-end activities are important activities in managing project complexity. Frequent follow-ups of this PSU have been mentioned as well and connect to the theory that the shared mental model needs to be frequently calibrated in order to remain effective. This results in a PSU with frequent follow-ups that are used to reduce the differences within the shared mental model. This is graphically visualised in figure 7.5.

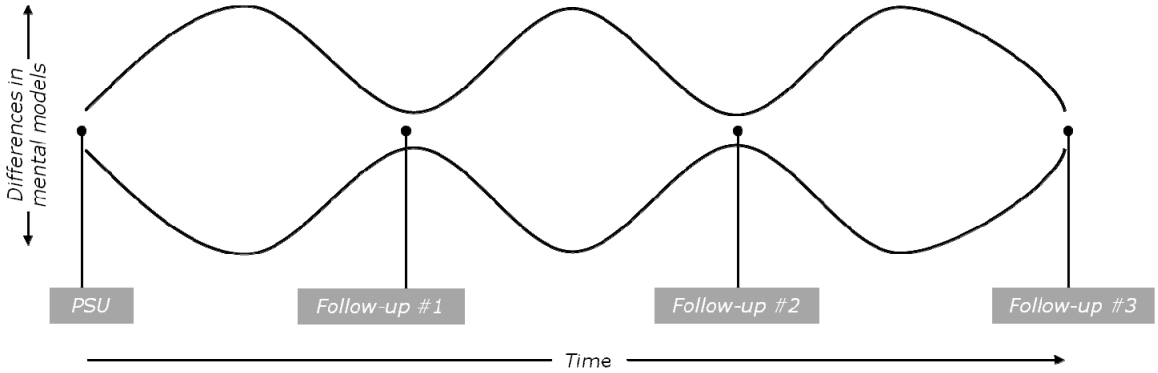


FIGURE 7.5 SEQUENCE OF THE PSU WITH CORRESPONDING FOLLOW-UPS

These activities must however not be seen as team-building activities but as moments to exchange perceived complexities. Team-building events may work counter effective since these events might not produce the expected results: Arnold and Silvester (2005, p. 534) clarify team building with four specific objectives of team building. These are: (1) the respect for team members and their views; (2) the ability of team members to challenge views and information; (3) the clarity of teams' goals and (4) the allocation of work.
They mitigate the expectations of team building and indicate that the overall contribution of team building activities is minimal. Team building seems to be the most effective when teams are relatively small and team-building interventions are short.

So who needs to take responsibility for the application of the interventions? This thesis regards perception-based management from the project-team's perspective and it is the opinion of this author that they should take the lead in managing perceived complexities since they form the crucial link in the process of realizing LCPs. This is validated within the theory of Davies and Mackenzie (2013) who define the systems integrator as the responsible person for combining all systems within a meta-system. The integrator relies on shared goals, formal contractual decisions and the cooperation between involved parties.
This integrator is however appointed by civil principals and they need to make a well thought-over decision in this matter.

Perception-based interventions that improve project learning
When preconditions have been established and the shared mental model is created the perceived complexities can be used in order to apply project learning.

The number of interventions mentioned during the interviews was relatively small and was limited to two interventions:

- *Provide space for other perceived complexities*. Once the perceived complexity of another is known it can and must be used within the project. The management approach should be flexible and leave room to implement the consequences of other perceived complexities.
- *Impersonate others' perceived complexities*. Involved individuals must impersonate the perceived complexities of others within their own organisations / followers. This ensures that their perceived complexity is taken into account when internal decisions are being made.

The internal validation with the project managers resulted in three interventions to apply project learning:

- *Embrace conceptual thoughts*. Construction practice seems to be focussed on detailed designs and plans rather than conceptual thoughts. However, concepts are very much suited for the exchange of ideas and information. If concepts are thought through and take into account all available information, the detailed design seems to follow automatically.
- *Embrace discussions*. Discussions are of vital importance to put the shared mental model to work. Therefore discussions need to be encouraged and stimulated. If the shared mental model is formulated correctly these discussions will not lead to friction but to extra information which can be used in the project.
- *Encourage individual responsibility*. The individuals must be capable of translating the shared mental model into actions. This requires responsible individuals who work independent. People must feel free to question the shared mental model and initiate the recalibration of this model: this means that people do not just follow bosses' orders but provide feedback.

The expert meeting resulted in multiple interventions that practitioners apply:

- *Trust employees*. Project management has to have trust in their employees and their skills and knowledge: they must be able to speak freely with counterparts in other parties without being controlled or restricted by project management. This requires trust from the project team because the employees need to check for themselves if certain communication is appropriate.

The earlier mentioned literature also provides different interventions that can be used to apply project learning. These authors will be elaborated below.

The shared mental model is mentioned as the way to apply project learning but this shared mental model is only one of the five principals in organisational learning (George & Jones, 2008). Other principals: (1) individuals need to develop personal mastery and (2) a complex mental model that challenges individuals to learn, develop and experiment. At a group level teams must be (3) able to use various kinds of groups to learn and (4) project managers need to apply a systems thinking approach to manage organisational learning on both an individual level as on a group level. The elaboration of these concepts extends beyond this research.

Reyes (2012) argues that individuals apply double-loop-learning to learn in complex projects (figure 7.6). Double-loop-learning reflects the consequences of actions not only to the action-strategy but also to the mental model. The same goes for organisations: members must be able to reflect on their shared mental model based on the consequences for the project that were the result of certain actions.

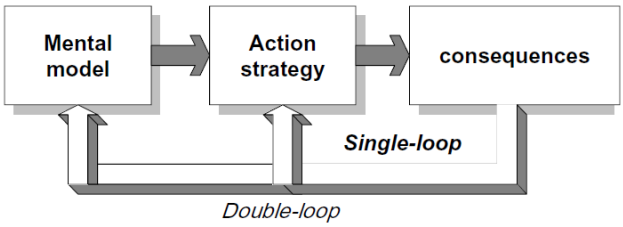


FIGURE 7.6 MODEL OF DOUBLE-LOOP-LEARNING. FROM: Reyes (2012)

Ahern, *et al.* (2013) emphasize the importance of shared and common project objectives and use the first landing on the moon as an example. This space journey could not be planned on beforehand since nobody knew what was going to happen but all team members had the exact same objective in their mind: to land on the moon.
They however disagree with double-loop-learning as the ideal way to deal with project complexity since this type of learning is capable of dealing with double-loop problems but not with complex problems. Double-loop problems are 'known unknowns' (i.e. risks): they are knowable problems. Complex problems are 'unknown knowns' which means that there is untapped knowledge available within complex problems.
This research however does not make a distinction between risks and complex problems but sees risks rather as a sub-component in project complexity. It is therefore argued that both applications (Reyes, 2012; Ahern, *et al.*, 2013) are useful in perception-based

management. This means that different perceived complexities can be used to apply double-loop learning and to discover the untapped knowledge within complex projects. This untapped knowledge can be used to understand the project actuality within LCPs.

7.3. Managerial implications of the research

The previous two paragraphs discussed the interventions dealing with project complexity and the interventions dealing with different perceived complexities. This paragraph indicates the implications for project management of LCPs. These managerial implications apply to PDOs.

7.3.1. *Managerial implications for dealing with project complexity*

This research led to the formulation of four managerial consequences for PDOs that can help them in managing project complexity within CPs.

1. Steer on a clear mandate from civil principals

PDOs that receive a clear and unambiguous assignment with enough space and flexibility to execute the project seem to be more successful than the PDOs that do not receive this assignment and freedom (determined on the judgement of project performance given for each case in chapter five). Receiving this assignment and freedom is however very difficult since decision-making between civil principals is a difficult process and these civil principals apply rather controlling interventions instead of providing space and flexibility.
The sooner the PDO can settle down its relation with the civil principals the more room there is for the other two important role-groups: local stakeholders and contractors. The sooner the PDO can focus itself on these two groups the better LCPs seem to perform: time is, together with enough budget and clear objectives, an important precondition to involve other actors.

PDOs can steer on a clear assignment with the necessary freedom. By initiating actuating interventions, the speed of the decision-making-process can be increased or decisions can even be enforced. Creating ownership by inviting all relevant civil principals into one consultation is an example of such an actuating intervention.

PDOs must not be reluctant to use strong controlling interventions at specific moments to obtain this clear assignment: these interventions have a take-it-or-leave-it-character and emphasize strongly that civil principals need to come to an agreement or that an assignment is unworkable.
PDOs must also not be reluctant to provide feedback on the decisions of the civil principals: if the available budget is for example too low or the projects' objectives are too vague the PDOs need to express this towards the civil principals.

The availability of enough time, budget and a clear assignment is referred to as a clear *mandate*. Steering on this mandate takes skills of PDOs: the project manager seems to play a vital role in this process. Civil principals seem to be more willing to provide this mandate when the project manager has built enough credit: some form of service record can help in receiving the necessary mandate. This credit is either based on previous successes of the project manager or historical successes of the project.

The organisational form can also make a difference for this mandate. PDOs that are organised in separate project bureaus which have the authority to hire independent people are much more independent PDOs that are part of the same organisation as (some of the) the civil principals.

2. Connect with the local stakeholders in the project

The *connection* of local stakeholders to the project should be preferred over *controlling* and managing the local stakeholders. This requires a different approach from PDOs but can result in a much better project performance.

Connecting to local stakeholders means that these local stakeholders must be seen as equal partners in a relationship rather than a subordinated partner in a hierarchy. Communication towards these external stakeholders must focus on transparency: being honest about risks, uncertainties and progress results in a different attitude of local stakeholders. Professional communication is the key in the successful involvement of the environment in the project.

PDOs must also focus attention to the connection between the contractor and the local stakeholders: these two role-groups are often directly interfaced in a project and good communication between the two can be of vital importance for the projects' performance.

Co-designing with local stakeholders uses the knowledge of these individuals and at the same time promotes a collaborative attitude of local stakeholders. PDOs must provide space for wishes and demands of local stakeholders, not only during the design phase of LCPs but also during the execution phase. This space includes flexibility in planning and budgeting. A profound example of such an intervention is switching the burden of proof: projects must prove that damage to the environment is not caused by the project rather that the environment needs to prove that damage is caused by the project.

PDOs must outsource the responsibility of defending the interests of the local stakeholders. By splitting these roles the PDO can focus on the interest of the project and does not need to balance the interests of the local stakeholders internally. This split includes the selection of independent parties to resolve differences: these parties must be agreed upon by both PDOs and local stakeholders.

3. Connect with the contractor but control if necessary
The connecting approach is often applied by PDOs towards contractors and this approach is indeed preferred by contractors. PDOs often however tend to maintain this approach too long which leads to decreased project performance: they must switch to the controlling approach at the right time.

The connecting approach must already be shown during the tendering phase: the approach can establish a strong basis for further collaboration if applied rightly. Physical on-sight communication is preferred by both PDOs and contractors and the organisational structure of the two parties need to be unambiguously clear to the other party: this helps practitioners to find their counterparts within the other actor.

The connecting approach must be maintained as long as possible and even beyond the point where it does not feel comfortable to the PDO anymore. However, if a contractor keeps failing in meeting expectations and demands, the PDO has to be willing to engage the contractor in a much more controlling approach.
This controlling approach must for example be applied if contractors do not behave as an integral design leader between subcontractors or if they fail to connect to the local stakeholders. PDOs must also become more aware of the fact that the contract with a failing contractor can be terminated: the PDO must not feel 'condemned' to one specific contractor.

PDOs on the other hand need to show themselves mature clients which know its responsibilities. Recent developments, for example the rise of the PPS-contracts, have shifted more responsibilities towards contractors: it would however be wise if PDOs do not shift all their responsibilities towards contractors but stay responsible for certain project components. An example is the responsibility to connect to the local stakeholders: although the contractor needs to apply this as well, the PDO must remain responsible for this component.

Another important precondition is the unambiguity of the (integrated) contract: contractual criteria have to be crystal clear and frame the appropriate and desired design flexibility. Ambiguous criteria lead to different interpretations on what the assignment truly is: a clear assignment is also in this relationship crucial to manage complexity (just as in the relationship between PDOs and civil principals).

4. Apply perception-based management
Different perceived complexities should be embraced and exploited by PDOs. The next paragraph will elaborate specifically on the managerial consequences of perception-based management.

7.3.2. *Dealing with project complexity: perception-based management*

Perception-based management can be applied in order to gain control on the project because it improves collaboration and it can be applied to improve project performance because it generates knowledge.
The following will sum up three managerial implications that together enable perception-based management.

1. Create the appropriate preconditions

Perception-based management requires five preconditions in order to be effective. The most important is the awareness of all involved individuals on the fact that differences in perceived complexities exist and that these differences can be potentially beneficial to project performance.

The right ambiance is the second important precondition. A safe environment is necessary in order to let people be honest and make them willing to share their perceived complexity.

Third, perception-based management requires a mandate from civil principals: civil principals need to become aware of the benefits on perception-based management so that they allow time and budget for perception-based management rather than focussing on short-term progress. This mandate is a sub-part of the mandate mentioned in the previous section.

Fourth, the right kind of people needs to participate in perception-based management. These people need to be able to apply the consequences of perception-based management independently and without the need for detailed instructions: they must be able to work independently. They also have to be willing to listen to others' perceived complexities and be willing to act upon those differences.
People that do not fit in this picture are likely to leave the project by themselves since they feel uncomfortable in the open and uncertain environment. If not than parties have to be willing to fire people from the project.

The last precondition is the advised use of contract types. Integrated contracts, especially D&C contracts, lead inherently to less possibilities to apply perception-based management and make it thereby more difficult. Traditional contracts and alliances are more suitable to apply perception-based management.
The selection of a contract type should however of course not be made dependent on the ability to perform perception-based management within that contract. It is therefore advised that PDOs take difficulties of integrated contracts for the application of perception-based management into account and prepare themselves for these difficulties: contractors should in that case be made much more aware of the necessity and tools to apply perception-based management.

2. Create a shared mental model

Creating a shared mental model is the first step in perception-based management. A shared mental model should contain a definition of the projects' objectives and a set of general norms and values which express the norms and values lived by the project and its involved practitioners: this requires example behaviour of key-individuals.

Project-start-ups allow involved practitioners to build a shared mental model. It is advisable to use professional and independent communicators to facilitate this creation: unbiased individuals are preferred over biased individuals as process leaders. The frequent follow-up of this PSU is necessary to recalibrate the shared mental model and make new people familiar with the DNA of the project.

Conversations must further more steer on personal values and motives of individuals rather than factual knowledge and skills. This focus can be carried out by asking the questions behind the questions and open questions. The initial state of confusion in a team must be accepted and used to create open minds to enable perception-based management.

3. Focus on project learning

The shared mental model must be applied by the individuals within their own roles. In this way the shared mental model leads to actions based on this model. Project learning can then be established in two ways: different perceived complexities can be used to enrich

available and tacit knowledge (e.g. in BIM or JRM) and they can be used to question the shared mental model.

By questioning the shared mental model (i.e. *double-loop learning*) the individuals indicate that the jointly constructed image is not applicable anymore and therefore the actions of the individuals (based on the shared mental model) may not result in the desired effects. By reshaping the shared mental model the project management approach adepts itself to the changed complexity within the project.

It is therefore important that individuals feel free to question the shared mental model. Discussions must be embraced and there must be room to make mistakes: mistakes can lead to a good recalibration of the shared mental model which prevents the mistake from being made again. It is therefore necessary that individuals are not punished for mistakes.
The recalibration of shared mental models must also be forced by organising follow-ups on the initial PSU. These follow-up 'check' if all projects' objectives, norms and values are still applicable in the current situation.

7.4. Limitations of this research

The research has shown its limitations. This paragraph points out three important limitations of this research.

The first and most important limitation is the explorative nature of the research and therefore the inadequateness of the collected data. The conclusions of this thesis must therefore be seen as points of references: perception-based management seems to be a meaningful addition to the project management of LCPs and the research provided enough evidence to assume a positive relation between perception-based management and project performance but it is too early for a sound conclusion: this would require more research.

Second the representativeness of the participated projects for the Dutch construction sector can be questioned. All participating projects were members of the KING/RPA network and were therefore above average informed about project management research and concepts. This might have resulted in a too positive image on awareness and opinions of different perceived complexities: respondents were likely to be familiar with these concepts before the research started. This even goes for the expert meeting: all participants were member of the KING/RPA network.

The third critical remark is the lack of knowledge on strategic behaviour of the respondents: there might be strategic considerations for individuals to share or not share their perceived complexity with others. This research assumed a lack of strategic behaviour but there were minor indications that this concept played a role within perception-based management.

8. Conclusions and further research

This thesis explained perceived complexities within LCPs and explored the implications of different perceived complexities on project performance and project management.

The main research question was defined as followed:

> **How do different perceived complexities impact project performance of LCPs and what are the implications for the project management of LCPs?**

This conclusion will answer this main question and recommend directions for future research.

8.1. Conclusions

This conclusion will combine all sub-conclusions mentioned at the end of each chapter. It will go through the content step-by-step.

Definition of project complexity
Project complexity is described extensively in literature and it acknowledges two types of complexities: detail complexity, which refers to the many components of a project that interrelate, and dynamic complexity, which refers to the unexpected consequences of these interrelations. The definitions of the two types are theoretical and high-level which does not make them very applicable to use in practice.
The operationalisation of this theoretical definition was only recently done by, among others, Bosch-Rekveldt (2011) who designed the TOE-framework to assess project complexity within construction projects.

This assessment, together with the in-depth interviews, showed that practitioners' definitions of project complexity differ in a high degree from the theoretical definitions of project complexity: definitions of practitioners are much more typified by the degree of influence that a practitioner has on the project complexity and the approach of this project complexity, being either problem focussed or challenge-focussed.

Different perceived complexities were described with the help of a designed lens model (based on a Brunswik Lens Model). The lens model seems to be a useful addition to the TOE-framework because it helps to better understand the assessment of the TOE-elements within the framework. This lens model was used to explain the origins of perceived complexities.

Origins of perceived complexities
The lens model showed that a perceived complexity is based on the selection of certain elements of the environment followed by a judgement on these elements. The TOE-elements were seen as environmental elements which were selected by respondents and then judged.

Selection of the top-3 TOE-elements seemed to be based on the following three parameters:

1. The (perceived) impact of a certain project-element on project performance and the degree of influence practitioners have on this element.
2. The experience of practitioners within other LCPs.
3. The contextual variables of a project.

Judgement of the top-3 TOE-elements seems to be based on the following parameter:

1. The interests of the practitioners within the project. These interests are drive by the role and/or the personal values of the practitioner.

These four sources do not all contribute in the same degree to each perceived complexity: some practitioners based their perceived complexity much more on a certain source then others.
Some practitioners based their perceived complexity for example on their experience while others based their perceived complexity more on the contextual variables of the project.
This research found indications that the sources *perceived impact* and *experience* were stronger indicators for a perceived complexity than the other two mentioned sources.

The use of the lens model within the TOE-framework and the determination of the four different origins of perceived complexities contributed to the knowledge field of management sciences which is operationalising the definition of project complexity so that it can be applied in construction practice. It also contributed to the knowledge field of management sciences which is looking for interventions to deal with project complexity.

Interventions dealing with project complexities
Literature identifies two types of approaches towards project complexity: the control-approach and the hands-off-approach. It is argued that successful project management combines both approaches.
Literature identifies three type of interventions within these two approaches (Best*, et al.*, 2013): controlling interventions (aimed to control the project), connecting interventions (aimed to connect people and ideas) and actuating interventions (aimed to move people towards actions or decisions).

The research identified four general specific preconditions to deal with project complexity: (1) physical interaction is the preferred way of communication; (2) roles must be split as much as possible within and between organisations; (3) informal networks must be created to act between rules and protocol; (4) the right kind of people need to be involved. Perception-based management was mentioned as important part in managing project complexity and is argued as the fifth important intervention to deal with project complexity.

Insights were furthermore provided by splitting the different interventions over four different roles of practitioners: the PDO, the civil principals, local stakeholders and the contractor. Not only did the research identify interventions which the four roles applied to manage complexity but it also identified interventions that were used to manage the collaboration between the four role-groups. The following list sums up the most important observations for PDOs that collaborated with the three other role groups:

- PDOs want flexibility and room to manoeuvre and therefore try to receive a clear assignment and mandate from civil principals. Civil principals however often apply controlling interventions: these interventions increase project complexity.
- Local stakeholders want to take part in the project and wish to be engaged with connecting interventions. PDOs however often still apply controlling interventions towards these stakeholders.
- Contractors need to be engaged with a balanced mix of connecting and controlling interventions.

It was also shown that the control-approach was sometimes enabled by applying connecting interventions and that the hands-off-approach was enabled by applying controlling interventions. This cross-application of intervention-types seems to be an addition to the current literature that argues the balanced management of the two approaches as a way to manage complexity.

Once the research understood perceived complexities and identified interventions dealing with complexity it focussed on the influence of perceived complexities on these interventions.

Perceived complexities and interventions dealing with project complexity
The research found enough evidence to confirm a link between interventions dealing with project complexity and perceived complexities. It remained however unclear what the cause-effect relation between the two is: either the presence of interventions leads to a certain perceived complexity or a perceived complexity leads to certain interventions.

It was also found that practitioners who perceive project complexity as a problem and have little influence on that project complexity might apply more controlling and actuating interventions than others. This is also a topic for further research.

After the influence of perceived complexities on interventions the influence of perceived complexities on project performance was researched. It was found that perceived complexities influence project performance directly and they might also influence project performance indirectly.

Perceived complexities and project performance
Different perceived complexities directly influence project performance: they thwart project performance if they remain unmanaged but they improve project performance if they are managed and used.

The direct influence of perceived complexities on project performance is assumed to be positive under the condition that differences in perceived complexities are exploited. Perception-based management enables PDOs to improve the collaboration with involved actors and to learn the unpredictable dynamic complexity of the project. It first brings all involved individual practitioners to a shared mental model which practitioners then apply to their action strategy and actions. Recalibration of this model enables project learning. Figure 8.1 shows this process graphically.

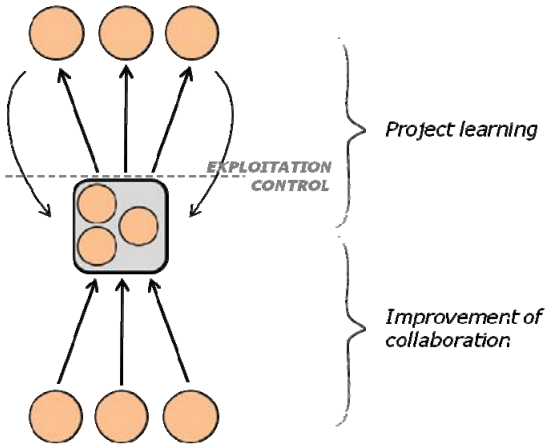


FIGURE 8.1 CONTRIBUTIONS OF PERCEPTION-BASED MANAGEMENT TO PROJECT PERFORMANCE

The indirect influence of perceived complexities on project performance would be via interventions dealing with project complexity. The consequences for performance remain however unclear: if different perceived complexities lead to certain interventions the perceived complexities influence project performance indirectly. If they are influenced by the interventions then they do not influence project performance indirectly.
This is shown graphically in figure 8.2.

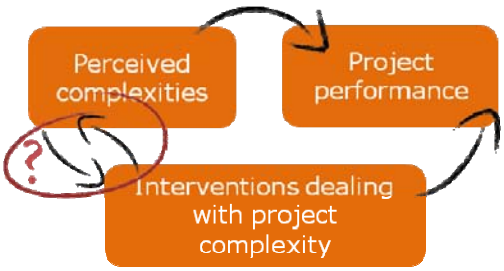


FIGURE 8.2 RELATIONS BETWEEN PERCEIVED COMPLEXITIES AND PROJECT PERFORMANCE

Application of perception-based management
Perception-based management leads to an improved collaboration between different practitioners and stimulates project learning within LCPs. The research identified three important steps in perception-based management: (1) PDOs must create the appropriate preconditions necessary to apply PBM; (2) PDOs must steer on the creation of a shared mental model and (3) the process of project learning needs to be brought to the core of project management.

The applications of PBM were validated within literature and thereby embedded in the current knowledge within management sciences.

8.2. Recommendations for further research

This research was mostly exploratory in its nature and therefore the number of unanswered questions is higher than before the research commenced.
This section indicates three directions for further research which followed from this research. It explains the research direction and concludes with a possible research question and hypothesis: these questions and hypotheses are the end-points of this research and the final contribution of this thesis to management sciences.

8.2.1. *Research direction one: relation between perception-based management and project performance*

The first direction focuses on the possible positive relation between project performance and perception-based management. It would require a systematic and, if possible, quantitative approach to judge project performance and a description of the detailed contents of perception-based management. By linking these two concepts and performing a case study research it can be found if there is a significant positive contribution of perception-based management to project performance.
The detailed description of perception-based management should also focus on the correct application of the two models designed in this research: when should which model be used in project management?
It should also be understood how strategic behaviour might be used by participating individuals and how this strategic behaviour impacts perception-based management.
Finally the description of perception-based management should especially focus on the phenomenon of project learning: how can project learning within perception-based management be optimally exploited?

> *Possible research question*: **what are the effective conditions for perception-based management to contribute positively to the performance of projects?**

> *Hypothesis*: **perception-based management contributes positively to projects' performance.**

Operational advices that can be used in the design of this research:

- A case study design is advised for this research. Construction projects should be selected on the degree to which they perform perception-based management: great contrasts are desired. To determine roughly if a project applies perception-based management the project manager can be asked if that person (1) acknowledges perceived complexities and (2) if that person eliminates, controls or exploits these perceived complexities.
- The step then is to provide a more detailed design of the models for perception-based management (figure 8.1). This helps to label the projects as ignoring, eliminating, controlling or exploiting and the detailed models must be used to answer the question to which extent the projects do so. For example: if a project is labelled as a project which exploits perceived complexities, it should be determined to which extent they exploit the different perceived complexities on a pre-designed scale.
- Use an existing method to assess project performance of projects. This assessment should be used to rank projects relatively to each other.
- The relation between perception-based management and project performance can now be determined: by statistically connecting the scale of perception-based management with the scale of project performance it can be determined if there is a significant relation between the both concepts.

8.2.2. *Research direction two: origins of perceived complexities and its effects on interventions dealing with project complexity*

The second direction is within the description of perceived complexities and its origins. This research showed that there are at least four different sources contributing to perceived complexities but it is unknown which sources contribute in which degree to a certain perceived complexity. There were minor indications found that the contribution of a source to a perceived complexity is determined by the role of practitioners.

A lens model was used to describe the perceived complexities but the use of this model can be extended to a mathematical degree in which it becomes statistically clear why certain TOE-elements are chosen as cues and what the correlation is between this selection and certain characteristics of practitioners.
A detailed direction of research could also be the exploration of *specific contextual variables* influencing perceived complexities: indications for six contextual variables were found but insights into which contextual variable leads to which perceived complexity can benefit the research on perceived complexities.

An important part of this research should be the relation between perceived complexities and interventions. This research showed that there is some kind of relation but much remains unclear: what are causes and what effects in this cause-effect relationship?
The research furthermore found evidence for the statement found in literature that project complexity can be influenced with the help of interventions. This influence could be part of this research direction.

> *Possible research question*: **what are the origins of perceived complexities from construction practitioners?**

> *Hypothesis*: ***experience*** **and** ***perceived impact*** **are more important contributors to a perceived complexity than** ***interests*** **and the** ***contextual variables*****. The degree of contribution of these sources depends on the role of the practitioner.**

Operational advices that can be used in the design of this research:

- The use of individual practitioners as units of analysis is advised for this research. Since it is believed that there is a relation between the role of practitioners and the contribution of certain sources, practitioners need to be selected based on role. By comparing practitioners with the same identified role within different projects this research can give a judgement on the influence of the role of practitioners on perceived complexities.
- Design a research which enables the statistical possibilities of the Brunswik Lens Model: the lens model can be used to statistically determine how much a certain source contributes to either the selection or to the judgement of cues of project complexity.
- Use the TOE-framework as the cues within this lens model. The constructed lens models in this research have shown that they provide useful grips to practitioners to describe project complexity. They must be treated as the individual variables which are set by the researcher.

8.2.3. *Research direction three: management approaches dealing with project complexity*

The third direction for future research is the management of project complexity. The research found evidence for the cross-application of interventions within the control-approach and the hands-off-approach. Mentions about this cross-application were not found within the researched literature and further research could improve the project management of project complexity.

The research also found evidence that there is a relation between perceived complexities and applied interventions to deal with project complexity. Further research should focus on the details of this relation. The author of this research believes that perceived complexities influence the applied interventions (bases on the interviews) and therefore suggests this statement as hypothesis for further research.

> *Possible research question*: how can practitioners best deal with project complexity?

> *Hypothesis*: the control-approach can be enabled with connecting interventions, the hands-off-approach with controlling interventions.
> *Hypothesis:* a perceived complexity influences and determines applied interventions dealing with project complexity

Operational advices that can be used in the design of this research:

- The units of analysis for this research could be projects that are already completed. In-depth interviews can be used to determine how complexity was managed (i.e. what were the applied interventions to deal with complexity) and what the effects of these interventions were according to the interviewees. If necessary, interviewees could be confronted with identified interventions from this research in order to stimulate answers without biasing them.
- These cause-effect-insights can then be analysed to see if controlling and connecting interventions were indeed used to make the 'other' approach possible and if these interventions were successful.
- Once perceived complexities are better understood (direction two, §8.2.2), research can categorise perceived complexity in a more meaningful way than this research and link the perceived complexities of practitioners to mentioned interventions by these practitioners. The framework of Best (2013) seems suitable for this comparison.

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Appendix A. Interview design

Interview project complexiteit. Interviewer: Bram Kool

Algemene instructies
- Creëer de juiste sfeer voorafgaand aan de introductie
- Verschaf definities waar nodig
- Vermijd complexe zinsconstructies
- Vermijd het geven van een eigen mening
- Vermijd serievragen en parallelvragen
- Neem de rol van de verwonderde student in: wees niet bang om naïeve vragen te stellen en vraag vanuit nieuwsgierigheid
- Lever antwoordinstructies
- Lever gevoelsreflectie

Top-3 thema's van geïnterviewde:
[Hier wordt de top-3 van de respondent ingevuld]

Top-3 elementen binnen het eerste thema:
[Hier wordt de top-3 van de respondent ingevuld]

Introductie van interview (5 minuten)
- Doel van het interview: inzichten krijgen in de motivaties en drijvers achter de antwoorden uit de enquête over project complexiteit (1); om informatie te krijgen over de omgang met complexiteit (2).
- Dat onderzoek wordt uitgevoerd door KING, RWS RPA en de TU Delft.
- De geselecteerde projecten zijn gekozen op basis van de grote differentiatie in antwoorden en type projecten.
- De geluidsopname dient voor mij om terug te luisteren zodat uw waardevolle antwoorden niet verloren gaan. Alleen ik heb toegang tot de geluidsbanden. Na transcriptie worden deze vernietigd.

- Rapportage vindt plaats middels een rapport met algemene conclusies en per project een deelrapport wat ook aan alle betrokkenen van het project wordt overhandigd.
- Het kan zijn dat de project manager dat deelrapport gaat gebruiken om management te verfijnen, maar dat is volledig afhankelijk van de project manager.
- Dit rapport doet geen specifieke aanbevelingen per project, maar alleen een deelrapportage van waargenomen feiten per project.

- De informatie die ik graag van u ontvang gaat ten eerste over uw achtergrond en blik op complexiteit binnen bouwprojecten en daarnaast op de management van project complexiteit in dit project.
- Dit duurt ongeveer 1 uur.
- Uw gegevens worden vertrouwelijk behandeld en komen anoniem terug in de algemene rapportage van het onderzoek.

- Vandaag zou ik enorm geholpen zijn wanneer u antwoord kunt geven op de vragen die ik u stel. Ik zal de tijd in de gaten houden en met u de vragenlijst doorlopen.

- Dit was de introductie, na eventuele vragen vanuit u ga ik nu graag over tot het afwerken van de vragenlijst.

Fase 1: persoonlijke, professionele feiten (10 minuten)
Allereerst zou ik u om wat feiten willen vragen over uzelf. Deze gegevens worden gebruikt om eventuele verbanden aan te tonen binnen de resultaten en komen niet persoonlijk herkenbaar terug in het algemene onderzoek.

Vragen	***Doel***
Vraag 1 alleen stellen mocht de rol van de geïnterviewde niet helemaal duidelijk worden uit de enquête 1. Wat is uw rol binnen het huidige project? 2. Wat zijn uw opleidingen en professionele werkervaring? 3. Wiens belangen vertegenwoordigt u in dit project? Hoe kenmerken die zich?	*Antwoorden 1, 2, en 3 moeten relevante feiten opleveren op de drie thema's die zij representeren*

Fase 2: vragen over complexiteit en management (30 minuten)
Dan gaan we nu verder met de volgende set vragen: de vragen over project complexiteit naar aanleiding van de enquête die u hebt ingevuld. Deze vragen zijn bedoeld als verdieping op de antwoorden die wij hebben ontvangen

Vragen	***Doel***
1. Uit de enquête blijkt dat u thema X (T, O of E) als het meest complexe thema waardeerde met daarbinnen de elementen X, X en X als top-3 bijdragers aan complexiteit. 1a. Kloppen deze gegevens nog steeds met uw huidige visie en beeld?	*Antwoord 1 dient de enquête resultaten te valideren en 1, 2 of 3 concrete situaties te beschrijven die door de rest van het interview gebruikt zullen worden.*
1b. Heeft u voorbeelden van concrete situaties waarin deze elementen zich toonden?	*Vraag 1b en 1c dienen gecombineerd per element gesteld te worden*
Alleen voor Project Managers: 1c. Hoe bent u omgegaan met deze elementen binnen het project? Graag interventies met specifieke en concrete gebeurtenissen die dit illustreren. In welke fase van het project is dit gebeurd? Wie waren daarbij betrokken? Wat waren de effecten?	*Antwoord 1c dient een lijst op te leveren met links gebruikte interventies, in het midden de fase waarin de techniek gebruikt is en rechts een voorbeeld van het gebruik.Trapgewijs stellen*
Voor de niet-Project-Managers: 1d. Hoe hebt u zelf, binnen uw huidige rol, uw eigen top-3 elementen bijdragend aan complexiteit gemanaged? Graag interventies met specifieke en concrete gebeurtenissen die dit illustreren. 1e. Hoe zijn de elementen [TOP-3 VAN PROJECT MANAGER] aangepakt binnen het project volgens uw inzicht? Graag interventies met specifieke en concrete gebeurtenissen waarin dit gebruikt had kunnen worden. *Let op: er dient een reflectie plaats te vinden op het handelen van de PM aangaande de drie elementen.*	
Voor iedereen 1f. Is deze top-3 project specifiek? *Zo ja:* waarom? In welk project (waar u hebt gewerkt) dan bijvoorbeeld? Welke specifieke situatie vond u toen wel/niet complex die nu anders is?	*Antwoorden 1f en 1g dienen een vergelijking te trekken tussen andere projecten en rollen om de motivatie voor de huidige top- 3 aan te scherpen.*

1g. Is deze top-3 rol-specifiek? *Zo ja:* waarom? In welke rol (die u eerder hebt gehad) dan bijvoorbeeld? Welke specifieke situatie vond u toen wel/niet complex die nu anders is?	
Alleen voor Project Managers: 2. Waarom komen nu juist deze 3 elementen uit de lijst van 50 bij u zo sterk naar voren? 2a. Welke situaties, gebeurtenissen en/of omstandigheden hebben er concreet aan bijgedragen dat u deze 3 elementen hebt genoemd? *Let op: niet op zoek naar uitingen van de top-3, zoals bij 1, maar naar bronnen van de top-3*	*Antwoord 2 dient een duidelijke inhoudelijke motivatie te geven voor de genoemde 3 elementen en enkele bronnen te benoemen voor de perceptie.*
Alleen voor de niet-Project Managers: 2b. De Project Manager noemde elementen X, X en X als top-3, u hebt deze elementen juist laag / ook hoog gescoord *(*voeg hier beschrijving toe van de overeenkomsten en verschillen van top-3 manager en top-3 geïnterviewde*)*. Waarom?	*Antwoord 2 dient een duidelijke oorzaak aan te wijzen van de verschillende scores op hetzelfde element*

Fase 3: vragen over perceptie verschillen (20 minuten)
Dit was de tweede fase van het interview. Dank u wel. De volgende set vragen zal gaan over verschillende percepties aangaande complexiteit zoals we die in fase 1 hebben waargenomen.

3. Was u zich voorafgaand aan dit onderzoek er zich van bewust dat er perceptieverschillen bestaan over complexiteit? *Zo ja:* Wat betekent dit voor u en uw werk? 3a. Hebt u een voorbeeld van een concrete situatie waarin die verschillen tot uiting kwamen?	*Antwoord 3 moet aantonen of mensen zich bewust zijn van perceptieverschillen en van situaties waarin die verschillen optraden en wat mensen toen deden.*
Alleen voor Project Managers: 3b. Hoe bent u omgegaan met verschillende percepties aangaande complexiteit? Graag interventies met specifieke en concrete gebeurtenissen die dit illustreren. In welke fase van het project is dit gebeurd? Wat waren de effecten?	*Antwoord 3b dient een lijst op te leveren met links gebruikte interventies, in het midden de fase waarin de techniek gebruikt is en rechts een voorbeeld waarin het daadwerkelijk gebruikt is.*
Voor de niet-Project-Managers: 3c. Hoe zijn de verschillende percepties gemanaged in het project naar uw inzicht? *Let op: er dient een reflectie plaats te vinden op het handelen van de PM aangaande de drie elementen.* 3d. Bent u bewust bezig met perceptieverschillen in uw doen en laten binnen het project? *Zo ja:* heeft u hier een voorbeeld / concrete situatie van.	
Voor iedereen: 3e. Hoe speelden perceptieverschillen een rol in de 3 voorbeelden die u gaf bij vraag 1? 3f. Bent u op dit moment op de hoogte van de percepties van andere actoren in het project team over complexiteit?	*Niet alle vragen (3e t/m 3g) hoeven gesteld te worden; ze staan hier vermeld om het gesprek op gang te houden mocht dat nodig zijn.*

Zo ja: hoe bent u hiervan op de hoogte geraakt? Wat voor acties hebben u of anderen daarvoor ondernomen?	
3g. Denkt u dat het belangrijk is dat iedereen zich in het team bewust is van perceptieverschillen? *Zo ja:* Waarom? Hoe zou u omgaan met die perceptieverschillen?	*Antwoord 3d vereist doorvragen. Het antwoord is altijd Ja, maar geldt dit nog steeds als dit bijvoorbeeld betekent dat men 3 weken inruimt voor dit proces?*

We zijn bijna aan het einde gekomen van het interview. Mij rest nog één laatste vraag:

1. Is er een vraag die u wel had verwacht maar die dit interview niet is gesteld?
2. Alleen voor Project Managers: mag ik eventueel in een later stadium nog een afspraak met u maken?

Afsluiting

Dat was de vragenlijst en daarmee het einde van het interview. Ik wil u vriendelijk bedanken voor uw bruikbare antwoorden. Nogmaals: dit gaat verwerkt worden in een algemene studie en een individueel case rapport, de laatste zal waarschijnlijk eind augustus opgeleverd worden.

Appendix B. Descriptions perceived complexities

This appendix displays the different perceived complexities of all respondents described with the help of the constructed lens model. It also sees if the role, education and interests of the respondent could be logically connected to this perceived complexity. The final section for each respondent describes the reaction of the respondent to the difference between the project manager and the respondent.
The description for respondent 22 could not be made, since this respondent did not indicate top-3 TOE-elements in the survey.

1.1. Analysis respondent 1

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B1.

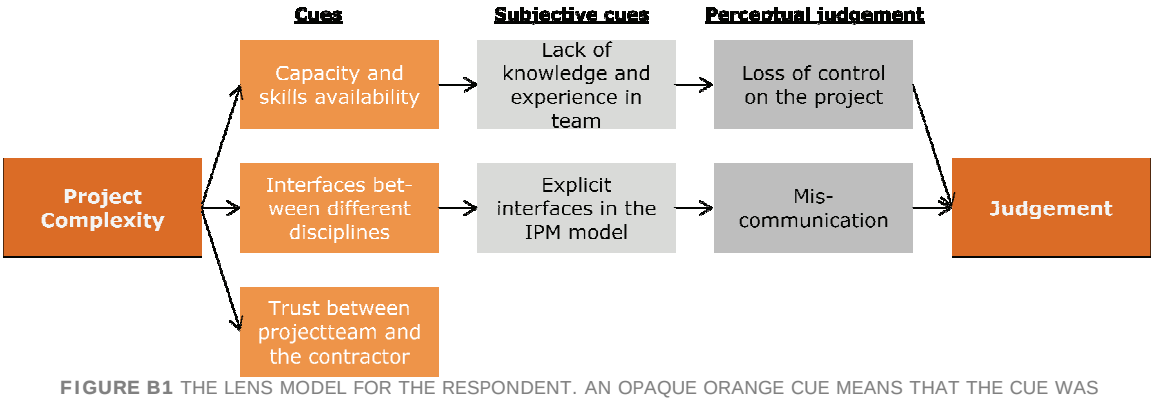


FIGURE B1 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

Both cues are based on challenges that the respondent is experiencing within its own project team. They are both judged as negative contributors to the project result.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent is the one of project manager, which makes the chosen cues especially applicable to the role of the respondent. It can therefore be stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests that the respondent represents are those of the municipality. At the same time the respondent indicates that these interests conflict with the interests of other municipal organizations. It is a task of the respondent to integrate these interests into one plan. It is therefore stated that the selection of the cues was connected to the stakes of the respondent. A summary of this is given in table B2

TABLE B2 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 1	Yes	●	○	●

1.2. Analysis respondent 2

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B3.

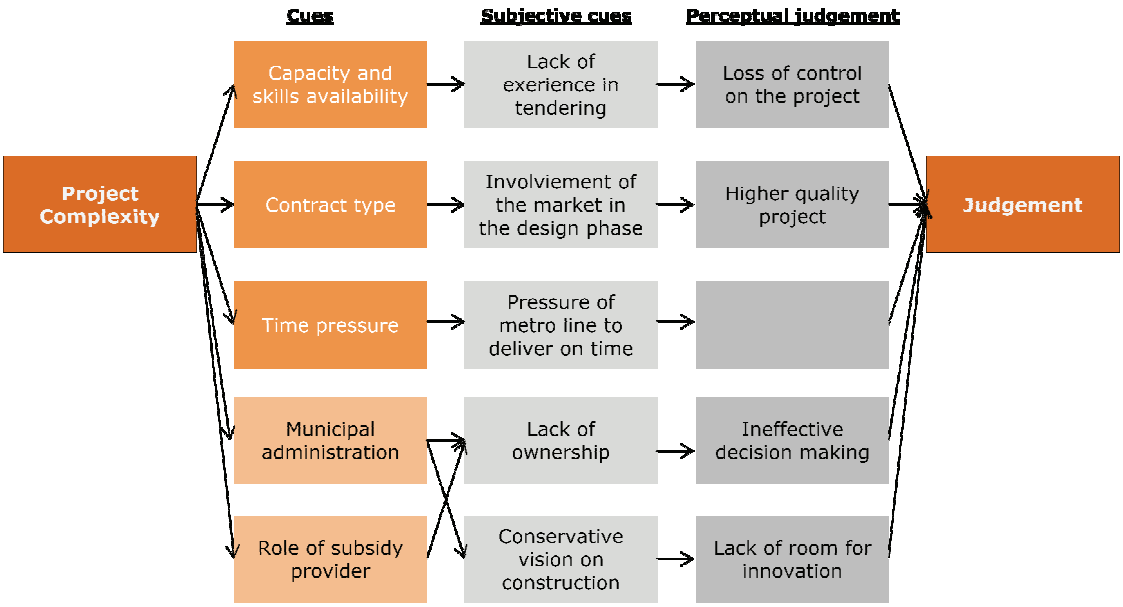


FIGURE B3 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The first two cues seem to be related to each other: the lack of tendering is exposed due to the choice to work with a D&C contract. The first cue leads to a negative project result, the second to a positive project result. The third cue seems to be a result of the first two cues and the last two cues are not project specific.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent is the one of civil client on behalf of the municipality. All five cues can be related to this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.

The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.

The interest that the respondent indicated to embody is the interest of the society and of politics. The interest of the society is served with a good quality project which the respondent thinks to achieve by a certain tendering process. All original (selected in the survey) cues refer to this tendering process, the ineffective decision making however does not. It is therefore stated that the selection of the cues was partly connected to the stakes of the respondent. A summary of this is given in table B4.

TABLE B4 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 2	Yes	●	○	◑

Reflection on the differences with the project manager

The respondent seems to recognize the chosen cues of the project manager, but does not share the perceptual judgements of the project manager. According to the respondent this elements should not be allowed to contribute to project complexity since they are elements that should and can be dealt with.

1.3. Analysis respondent 3

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B5.

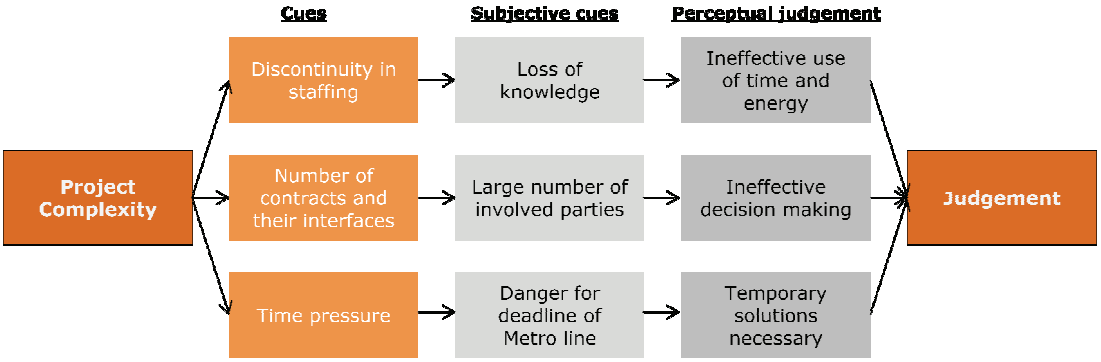


FIGURE B5 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

All cues are eventually judged as negative contributors to the project result. The second cue appears to be another cue which was also available in the survey.
Furthermore, since the respondent did not mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies outside the circle of influence of the respondent.

The role of the respondent was limited to the technical interface of the project with another project. None of the cues refer to an aspect which is directly related to the role of the respondent (the interfaces between contracts is replaced by a cue on the large number of involved parties). It is therefore stated that the selection of the cues was minimally connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests of the organization of the respondent are based on the project which interfaces with the project of the case. In this interfacing project, the ultimate goal is to deliver on-time. This is reflected within all cues of the respondent, which are all judged as some form of time delay. It is therefore stated that the selection of the cues was connected to the stakes of the respondent. A summary of this is given in table B6.

TABLE B6 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 3	No	○	○	●

Reflection on the difference with the project manager

The respondent seems to recognize the chosen cues of the project manager and realizes that his judgement on those cues might not have been correct. This is due to the fact that the respondent did not look at the problems from a project managers' perspective.

1.4. Analysis respondent 4

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B7.

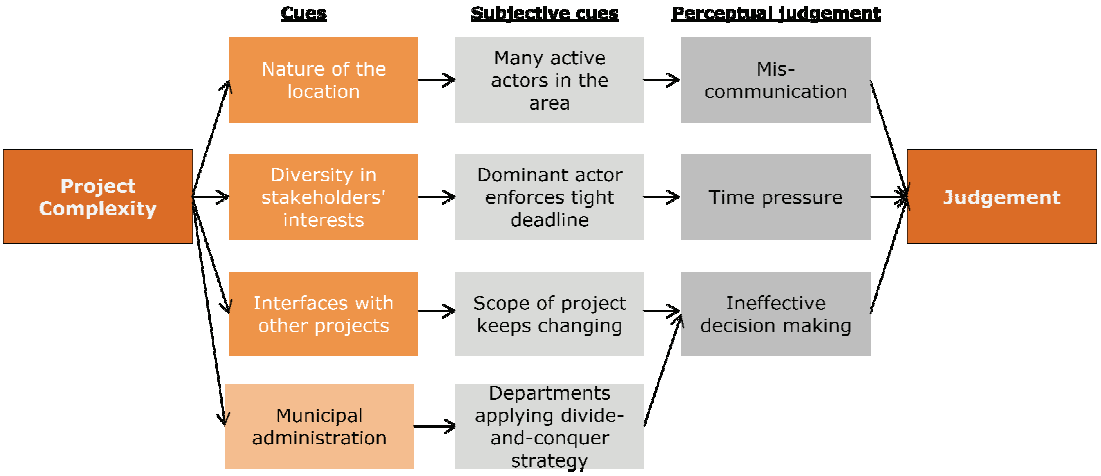


FIGURE B7 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

All the selected cues, which are originally external, are transformed into organizational challenges. All these challenges are judged as negative contributors to the project result. Furthermore, since the respondent did not mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies outside the circle of influence of the respondent.

The role of the respondent was limited to the technical design of the project. None of the cues refer to an aspect which is directly related to the role of the respondent. It is therefore stated that the selection of the cues was minimally connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests of the respondents' own organization conflict with the interest of the project, according to the respondent. This is in line with the statement that the complexity is created due to a fragmented municipal administration. It is therefore stated that the selection of the cues was connected to the stakes of the respondent. A summary of this is given in table B8.

TABLE B8 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 4	No	○	○	●

Reflection on the difference with the PM

The respondent seems to recognize the chosen cues of the project manager, but does not share the perceptual judgements of the project manager. According to the respondent this elements should not be allowed to contribute to project complexity since they are elements that should and can be dealt with.

1.5. Analysis respondent 5

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B9.

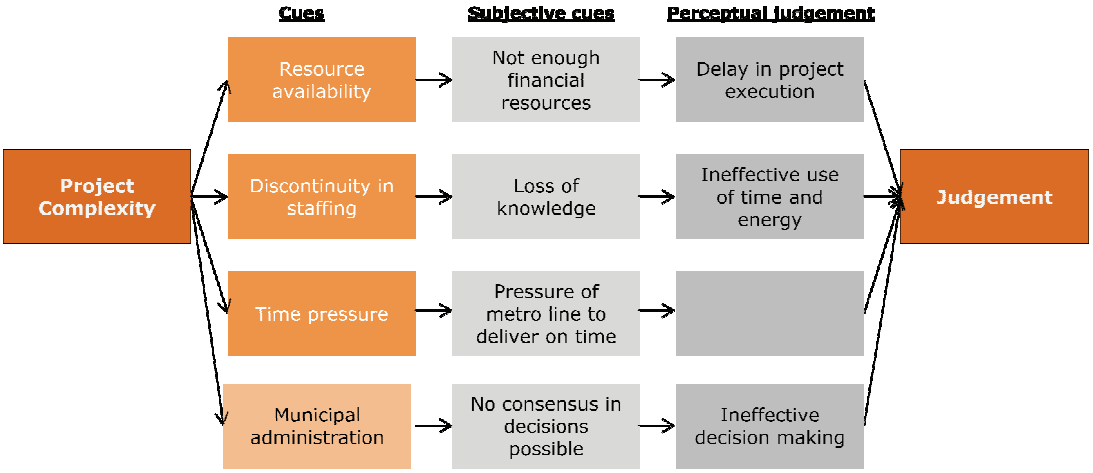


FIGURE B9 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

All selected cues are transformed and judged as negative contributors to the project result. Furthermore, since the respondent did not mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies outside the circle of influence of the respondent.

The role of the respondent is the one of subsidy provider on behalf of the municipality. The first cue seems to relate to this role, since it addresses the issue of financing. All other cues do not seem to affect the role of the respondent directly. It is therefore stated that the selection of the cues was partly connected to the role of the respondent.
The educational background of the respondent is urban planning. Since none of the cues refer to the urban planning process, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interest that the respondent indicated to embody is the interest of traveller. It is in the interest of the traveller that the project finishes on time (due to the connection with the metro line). Since all cues of the respondent are eventually judged as time issues, it is stated that the selection of the cues was connected to the stakes of the respondent. A summary of this is given in table B10.

TABLE B10 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 5	No	◑	○	●

Reflection on the differences with the project manager

The respondent seems to recognize the chosen cues of the project manager, but does not share the perceptual judgements of the project manager since these cues cannot be judged by the respondent (because the respondent has no access to the information necessary to judge the cues).

1.6. Analysis respondent 6

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B11.

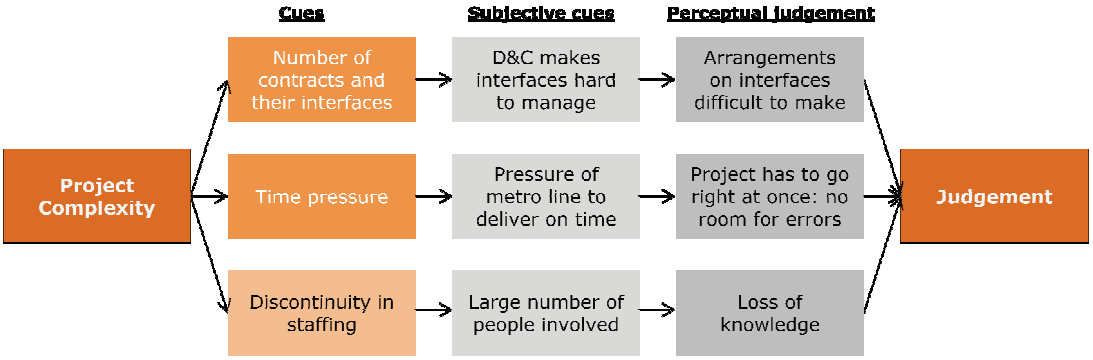


FIGURE B11 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The first cue is transformed into another cue which could have also been selected in the survey. All cues result in a judgement which contributes negatively to the project.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was focussed on the technical design of the project. Some of the selected cues refer to this role (number of contracts and time pressure), others do not (discontinuity in staffing). It is therefore stated that the selection of the cues was partly connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the municipality and the organization within the municipality responsible for the execution of the project. It is in the interest of the municipality to deliver the project on time (in order not to interfere with the other project's schedule) and that the interfaces are well managed (in order to ensure a smooth connection between bus station and metro line). It is therefore stated that the selection of the cues was connected to the stakes of the respondent. A summary of this is given in table B12.

TABLE B12 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 6	Yes	◑	○	●

Reflection on the difference with the project manager

The respondent seems to recognize the chosen cues of the project manager but only after they were mentioned by the interviewer. The judgement of the project manager on these cues is also recognized and agreed upon by the respondent.

1.7. Analysis respondent 7

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B13.

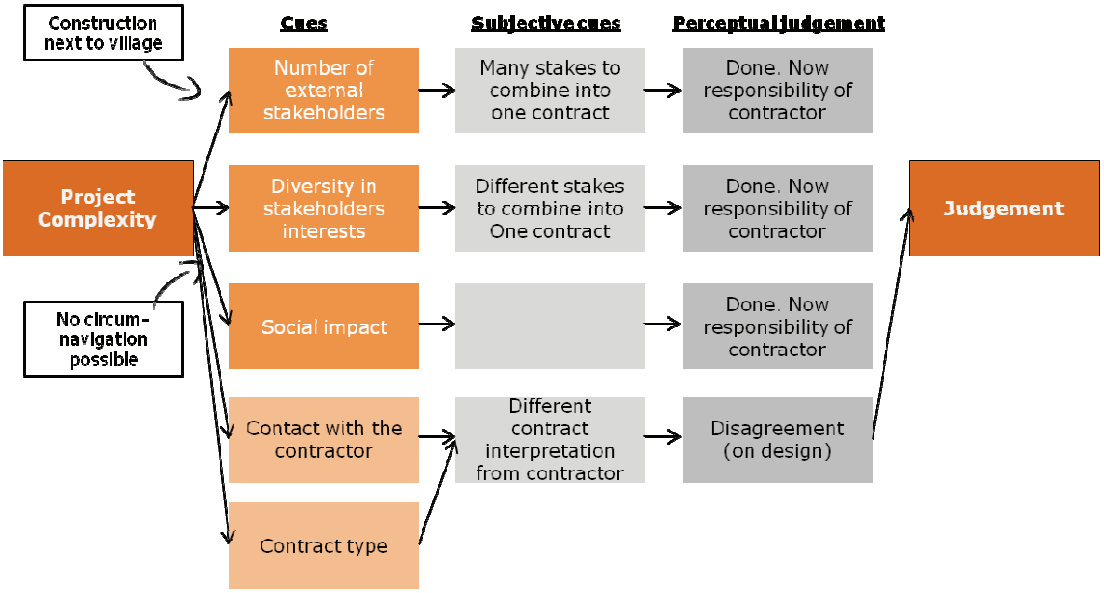


FIGURE B13 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The first three cues refer to situations that are not judged as complex anymore by the respondent, since these cues are not the responsibility of the respondent anymore. Complexity for the respondent now lies in disagreement between the project team and the contractor, caused by the contract and the contact. The cues result in a negative situation for the project.
Noteworthy are the two objective cues mentioned by the respondent that result into the first two cues.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of project manager. The selected cues do not necessarily relate directly to this role (it are all cues that have other roles as direct counterpart). It is therefore stated that the selection of the cues was minimally connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the secretary and of the direct environment, thereby not hindering the internal waterways. This is directly related to the first three cues, which all refer to environmental elements. It is therefore stated that the selection of the cues was connected to the stakes of the respondent. A summary of this is given in table B14.

TABLE B14 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 7	Yes	○	○	●

1.8. Analysis respondent 8

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B15.

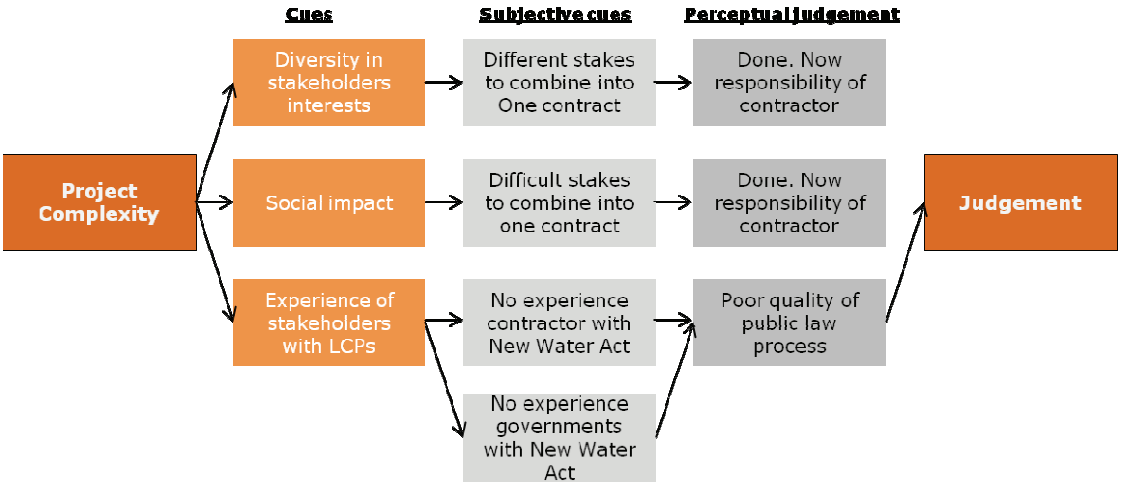


FIGURE B15. THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The first two cues refer to situations that are not complex anymore since the contract has been made and the external environment is now the responsibility of the contractor. The third cue is translated into the lack of experience of parties regarding the new water act and results in a negative judgement for the result.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was focussed the juridical component of the project, in specific the public law component. Some of the selected cues refer to this role (experience of stakeholders), others do not (diversity of interests and social impact). It is therefore stated that the selection of the cues was partly connected to the role of the respondent.
The education of the respondent is of a juridical character. Since some of the cues refer to juridical complexities, it is stated that the selection of the cues was partly connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the public cause by motivating and preparing decisions. Since all cues are related to this stake (the respondent indicated that you deal with different interests by explaining the public law rules). It is therefore stated that the selection of the cues was connected to the stakes of the respondent. A summary of this is given in table B16.

TABLE B16 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 8	Yes	◑	◑	●

Reflection on the difference with the project manager

The respondent agreed with the project manager on the selection and judgement of the cues.

1.9. Analysis respondent 9

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B17.

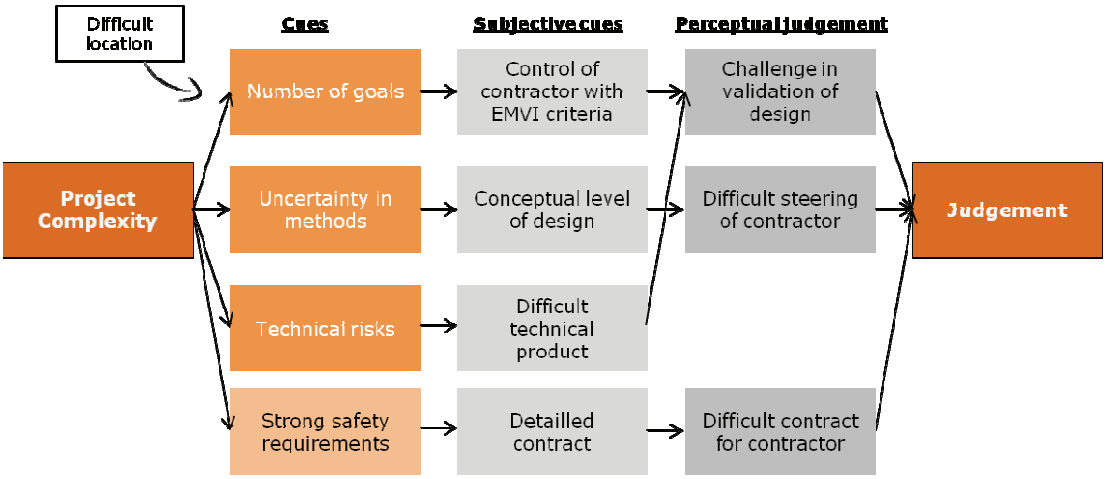


FIGURE B17 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

All cues refer to the difficult and detailed contract which result in a challenging contact with the contractor. The judgements are do not refer explicitly to negative impacts for the project but more to challenges coming forward out of the contract. The difficult location has been mentioned as objective cue leading to the strong safety requirements and number of goals.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was to keep in contact with the contractor. All of the selected cues refer to this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. All of the cues refer to technical complexities, but there is no evidence that this has anything to do with the education of the respondent: they are a result of the role of the respondent according to the respondent. It is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the public cause by providing safety and the responsible use of money. Both interests are directly reflected in the selection of cues and judgements. It is therefore stated that the selection of the cues was connected to the stakes of the respondent. A summary of this is given in table B18.

TABLE B18 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 9	Yes	●	○	●

Reflection on the difference with the project manager

The respondent seems to recognize the chosen cues of the project manager, but does not share the perceptual judgements of the project manager since the contract manager judges the external cues from a contractual perspective, and they do not form a contractual risk anymore.

1.10. Analysis respondent 10

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B19.

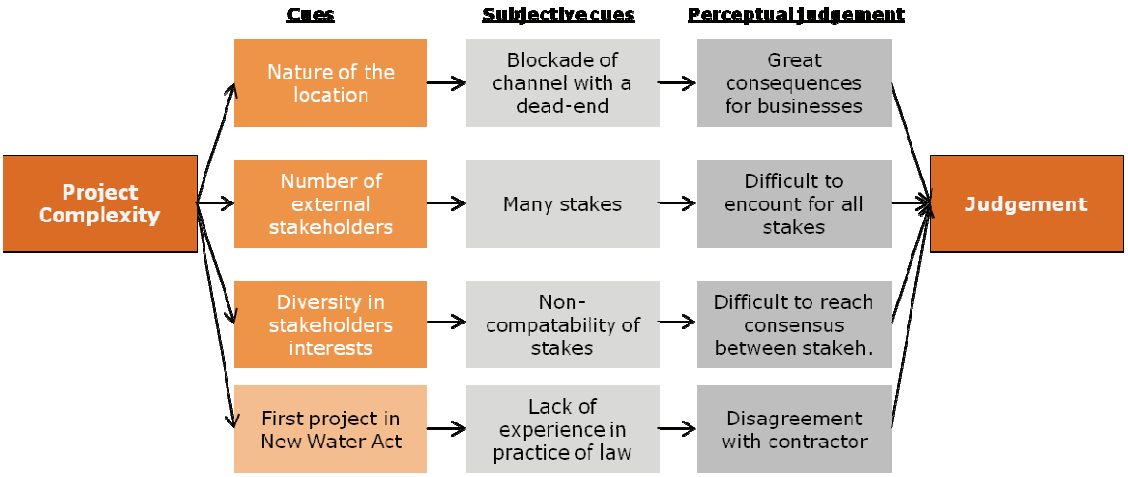


FIGURE B19 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

All cues refer to the environment of the project and the challenges within that environment. Although the contract has been signed, the respondent still identifies these cues. The last cue was mentioned in the interview, but immediately reduced in priority: the external elements are the contributors to complexity according to the respondent.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was to keep in contact with the environment. All of the selected cues refer to this role, except for the last but that was downscaled in importance in the interview. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is physical geography. None of the cues refer to elements of this education (except for the first element, but this is not judged on physical aspects but on the effects of usage). It is therefore stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of society and the interests of the environment. All cues refer to the last interest, it is therefore stated that the selection of the cues was connected to the stakes of the respondent. A summary of this is given in table B20.

TABLE B20 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 10	Yes	●	○	●

Reflection on the difference with the project manager

The respondent does not seem to recognize the 'social impact' cue of the project manager and can therefore not identify why this cue was chosen by the project manager.

1.11. Analysis respondent 11

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B21.

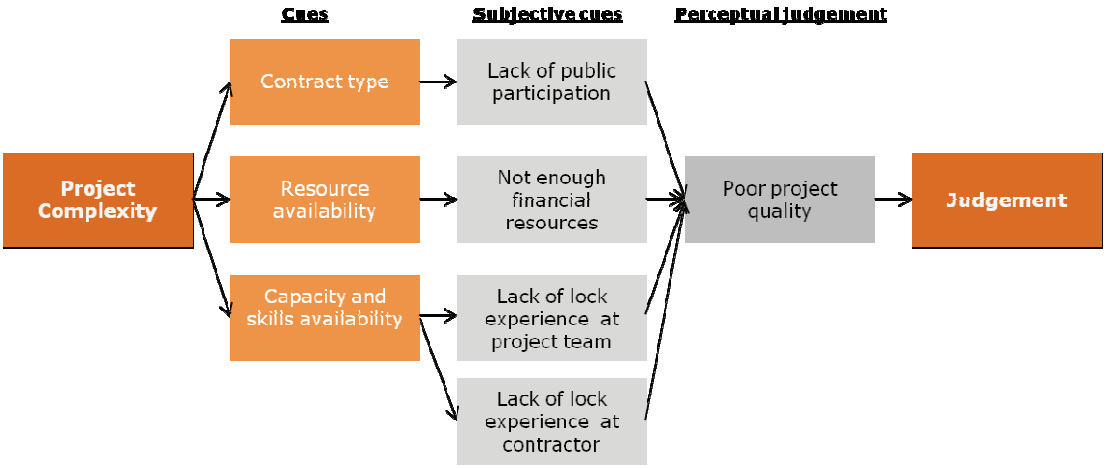


FIGURE B21 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

All selected cues refer to one single judgement: the poor quality of the project. It is clear that the cues result in a negative impact for the project according to the respondent.
Furthermore, since the respondent did not mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies outside the circle of influence of the respondent.

The role of the respondent was to defend the interests of the skippers in the project. All of the selected cues refer to this role, since all cues are translated in the quality for the project to the internal waterways. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is logistical. The cues refer to the quality that influences the functioning of logistical usage, but this is at the same time the interest that the respondent supposed to defend in the project. The own education experience of the respondent however does seem to play a role determining this project quality. It is therefore stated that the selection of the cues was partly connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of skippers. All cues refer to this, it is therefore stated that the selection of the cues was connected to the interests of the respondent. A summary of this is given in table B22.

TABLE B22 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 11	No	●	◑	●

Reflection on the difference with the project manager

The respondent does seem to recognize the chosen cues of the project manager but does not judge them the same since the elements do not affect the respondent in functioning and are project-manager-specific.

1.12. Analysis respondent 12

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B23.

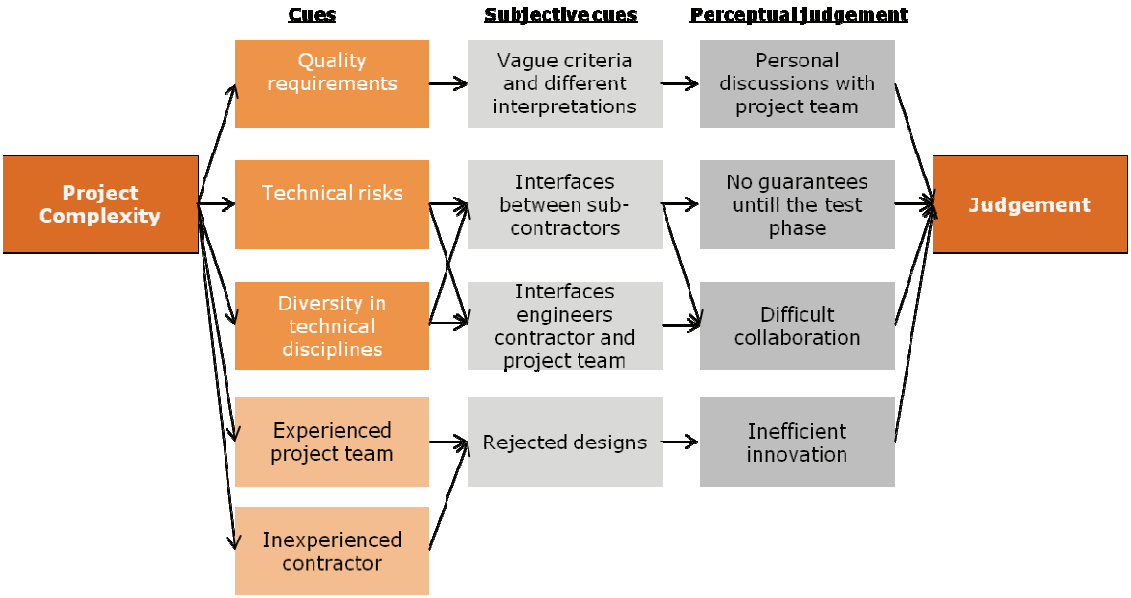


FIGURE B23 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues all result in perceptual judgements that deal with collaboration. Especially the collaboration between the project team and the contractor is criticised, where the acceptance procedure is most criticised. The cues are result into negative impacts for the project.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of contractor. All of the selected cues refer to this role, since all cues relate to the collaboration between contractor and project team. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. All selected cues are technical, but the perceptual judgements all focus on organizational problems, it is therefore stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the contractor, aiming to build a project in which the relations with the project team would be good. Since almost all cues refer to this relationship and the quality of that relationship, it is stated that the selection of the cues was connected to the interests of the respondent. A summary of this is given in table B24.

TABLE B24 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 12	Yes	●	○	●

Reflection on the difference with the project manager

The respondent does seem to recognize the chosen cues of the project manager but does not judge them the same since the respondent does not have enough information on this area in order to judge the elements.

1.13. Analysis respondent 13

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B25.

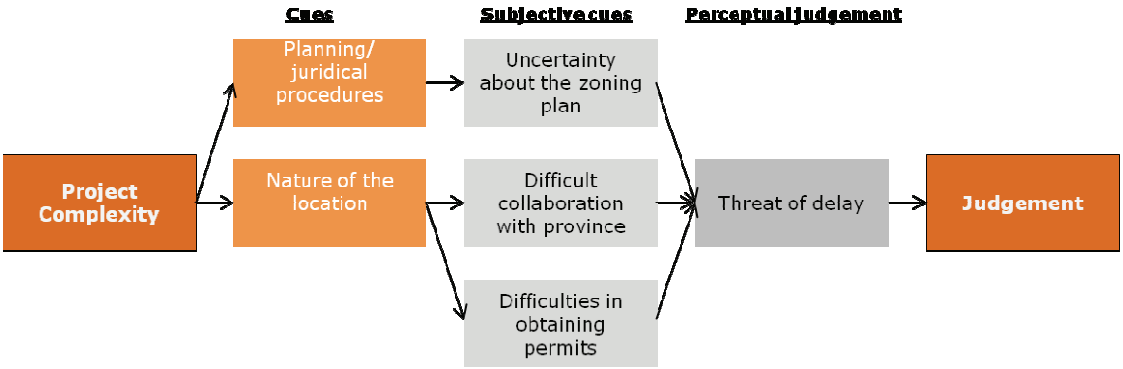


FIGURE 25 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues all result in the perceptual judgement of (a threat of) delay. The cues are therefore perceived to have a negative impact on the project.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one project leader within a municipality. None of the selected cues refer to this role. It is therefore stated that the selection of the cues was minimally connected to the role of the respondent.
The education of the respondent is of a juridical character. The selected cue refers to this education and the respondent indicated that selection was partly based on education, it is stated that the selection of the cue was connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the municiaplity, translated into a number of demands including an on-time delivery. Since this element is however not mentioned as most important element in the municipalities' interest, it is stated that the selection of the cue was partly connected to the interests of the respondent.
A summary of this is given in table B26.

TABLE B26 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 13	Yes	●	○	●

1.14. Analysis respondent 14

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B27.

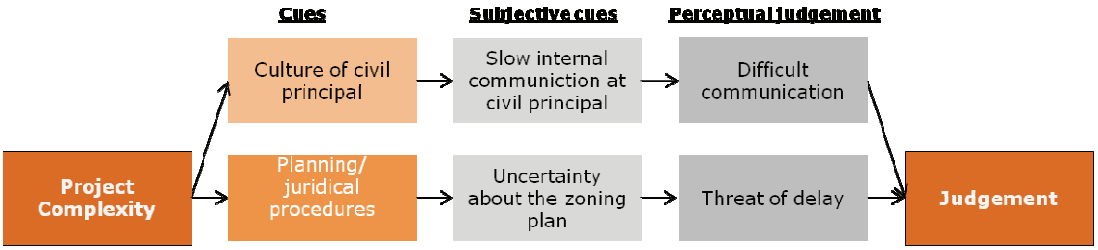


FIGURE B27 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cue was identical to the one of the process manager as was the perceptual judgement. The element of the culture of the civil principal was mentioned during the interview but was mitigated right away by stating that this communication was now in the hands of a consortium.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of contractor. All of the selected cues refer to this role, since all cues relate to the collaboration between contractor and project team. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. All selected cues are technical, but the perceptual judgements all focus on organizational problems, it is therefore stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the contractor, aiming to build a project in which the relations with the project team would be good. Since almost all cues refer to this relationship and the quality of that relationship, it is stated that the selection of the cues was connected to the interests of the respondent. A summary of this is given in table B28.

TABLE B28 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 14	Yes	○	●	◑

Reflection on the difference with the process manager

It turned out that the process manager and the respondent agreed on the element, but both used another interpretation of the element in their judgement.

1.15. Analysis respondent 15

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B29.

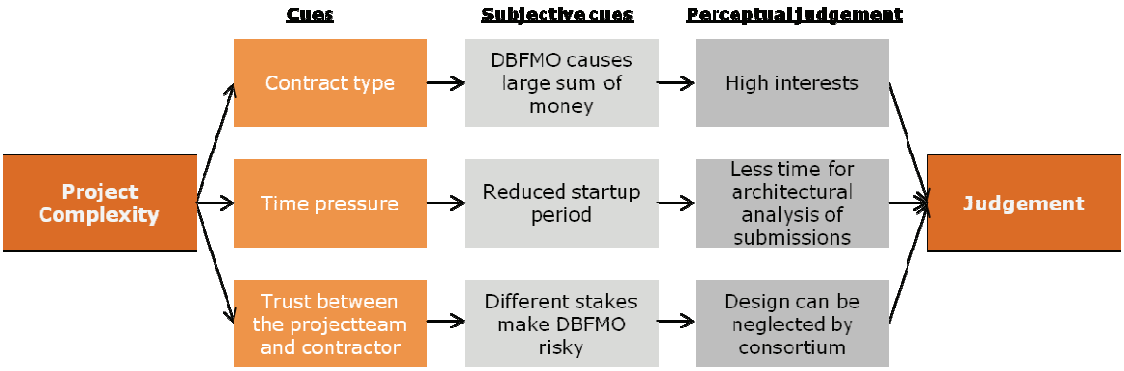


FIGURE B29 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues all come down to 'classic' elements: time, money and people. These elements always make projects complex according to the respondent. The first cue translates in a neutral judgement, both other cues translate into judgements which impact the project slightly negative (the judgements are given as a chance on a negative impact but the judgements themselves do not imply immediate negative impact).
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of architect. The two last selected cues refer to this role, since they impact the work of the architect. It is therefore stated that the selection of the cues was partly connected to the role of the respondent.
The education of the respondent is of a technical character. None of the selected cues is technical, but the respondent stated that the selection of the cues was based on his experiences as architect. It is therefore stated that the selection of the cues was partly connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the state, aiming to build a project in which quality is guaranteed. Since almost all cues refer to this quality, it is stated that the selection of the cues was partly connected to the interests of the respondent. A summary of this is given in table B30.

TABLE B30 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 15	Yes	◑	◑	◑

Reflection on the difference with the process manager

The respondent does not experience the project complexity within the elements of the process manager because it is not his responsibility.

1.16. Analysis respondent 16

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B31.

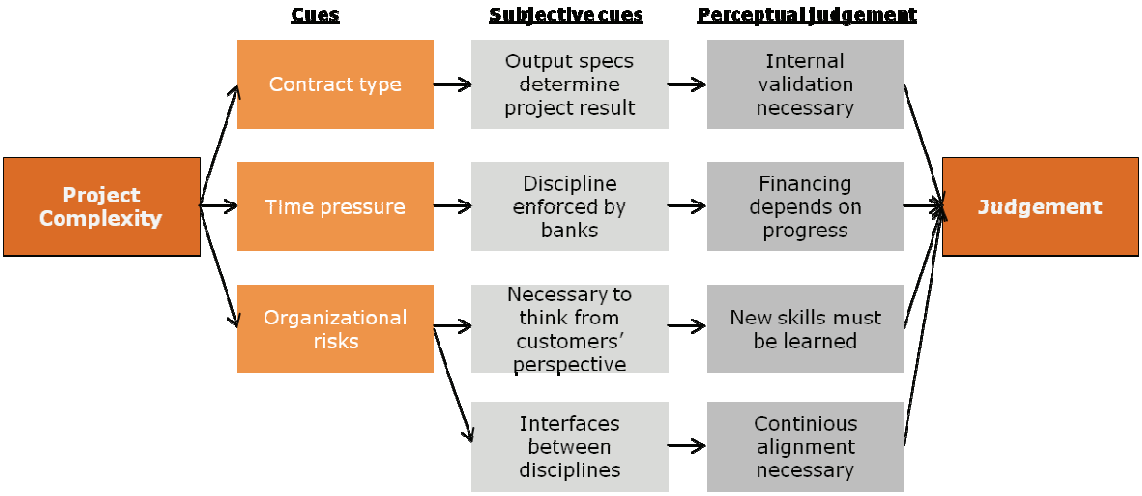


FIGURE B31 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues all refer to a judgement which relates to the PPP construction. The contract type asks internal validation, the financing through banks causes time pressure and the operation part demands new skills of the constructor. Perceptual judgements do not translate as negative impact on the project: they are more challenges to meet and once achieved they can benefit the project or organisation.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of project director. All selected cues refer directly to tasks that need to be performed from this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the company, aiming to build a qualitative project and learn the skills necessary for PPP projects. The perspective is strongly focussed on the learning aspect of the team, it is therefore stated that the selection of the cues was connected to the interests of the respondent. A summary of this is given in table B32.

TABLE B32 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 16	Yes	●	○	●

Reflection on the difference with the process manager

The respondent does recognize the cues selected by the process manager, but indicates that he doesn't have influence on them. Therefore he does not share the judgement with the process manager.

1.17. Analysis respondent 17

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B33.

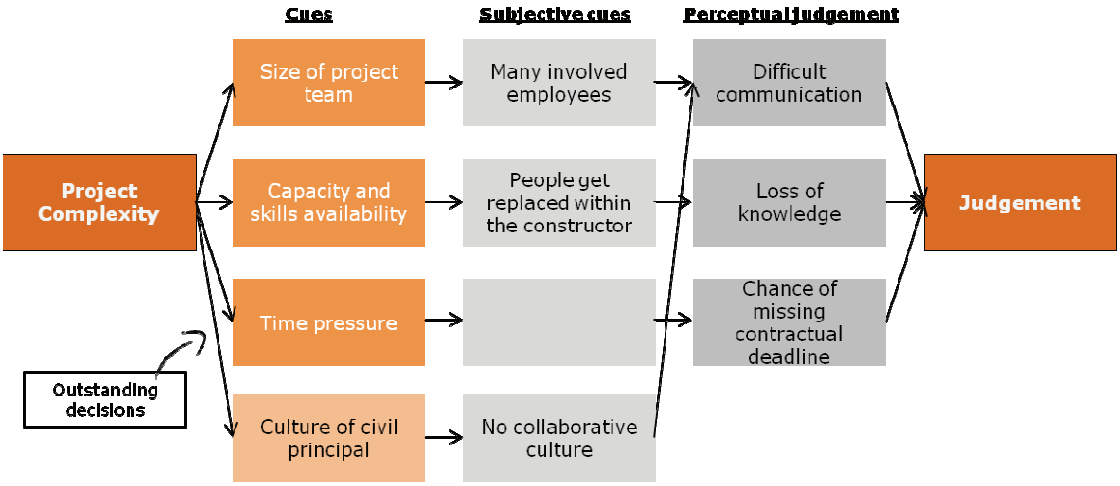


FIGURE B33 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The first two selected cues are judged as organizational challenges between the actors. The time pressure causes a chance of missing the contractual deadline and is drive by the objective cue of decisions that still need to be made. All cues result in judgement that might have a negative impact on the project but necessarily so.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of environmental manager. Only the first cue refers to tasks that need to be performed by this role. It is therefore stated that the selection of the cues was minimally connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the company and therefore the interests of the future visitors. The perspective is not focused on the future visitors nor their experience, it is therefore stated that the selection of the cues was minimally connected to the interests of the respondent. A summary of this is given in table B34.

TABLE B34 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 17	Yes	◯	◯	◯

Reflection on the difference with the process manager

The respondent does recognize the cues selected by the process manager, but explains that the judgement is different because the source behind these elements is the reason for complexity. That source is the number of actors involved.

1.18. Analysis respondent 18

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B35.

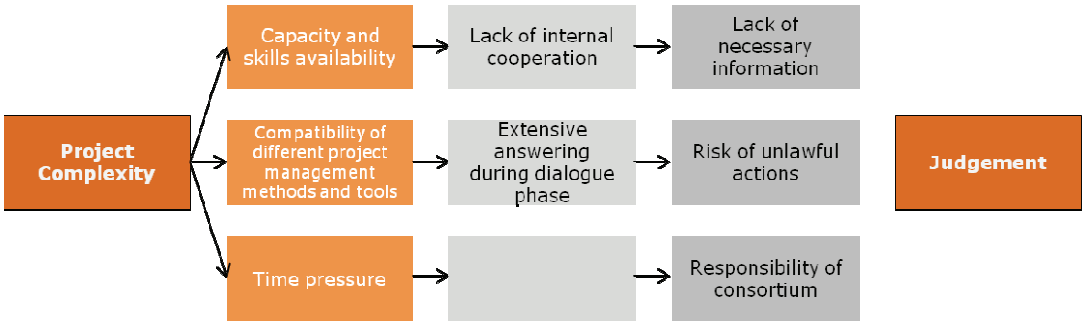


FIGURE B35 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

All selected cues referred to situations that have occurred and therefore do not contribute to complexity anymore. The lack of information has been solved and the dialogue phase went according to plan. The time pressure is now the concern of the consortium.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.
The role of the respondent was the one of project manager. All cues refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.

The interests the respondents indicated to embody are the interests of the ministry that acts as civil principal. These interests consisted of a project being delivered within the budget and of good quality. The perspective is not focused on the quality but is on time, which translates itself into money. It is therefore stated that the selection of the cues was partly connected to the interests of the respondent. A summary of this is given in table B36.

TABLE B36 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 18	Yes	●	○	◑

Reflection on the difference with the process manager

The respondent would have judged the differing element more complex in retro-perspective, because everything that could have gone wrong went wrong.

1.19. Analysis respondent 19

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B37.

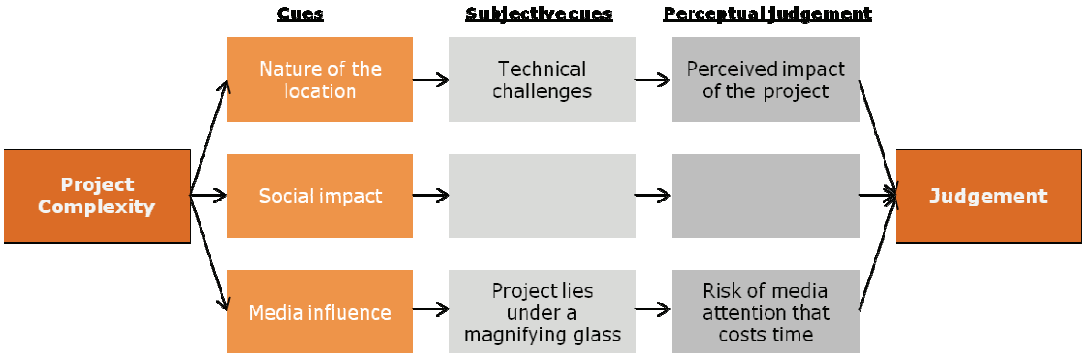


FIGURE B37 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues are externally focussed all result in a judgement which contributes negatively to project result. Although the nature of the location is interpreted into technical challenges, the judgement refers back to an external situation.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.
The role of the respondent was the one of project manager. All cues refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.

The interests the respondents indicated to embody are the interests of the municipality. These interests consist of a project being delivered while maintaining a good relationship with the external surrounding. The perceived complexity focuses itself fully on that relationship. It is therefore stated that the selection of the cues was connected to the interests of the respondent. A summary of this is given in table B38.

TABLE B38 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 19	Yes	●	○	●

1.20. Analysis respondent 20

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B39.

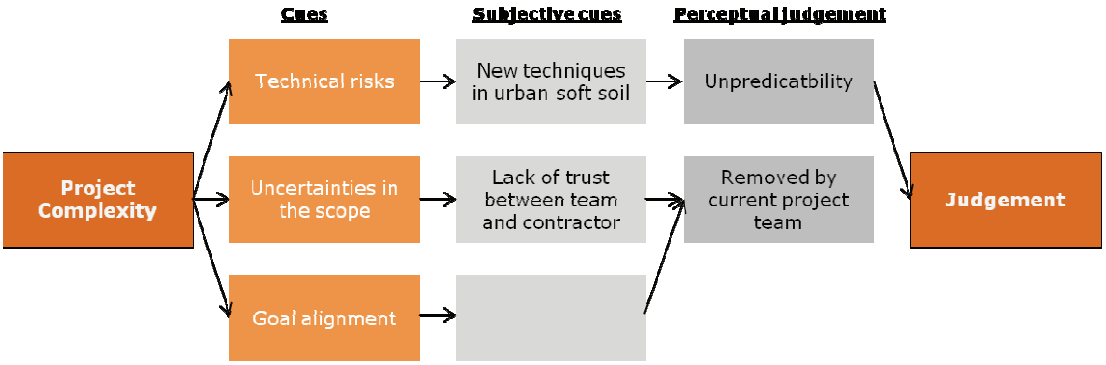


FIGURE B39 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues were chosen based on the bad relationship between contractor and project team. Due to the improved project management from the project team, the last two cues became less valid. Technical risks will always be a part of the project and cannot be removed. The last two cues referred to a situation that had a negative impact on the project, the first cue is judged as a possible negative contributor to project result.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of project director for the contractor. All cues refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. The cue of the technical risks refers to technical challenges, the other two cues referred to organizational mistakes. It is therefore stated that the selection of the cues was partly connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the company. These interests consisted of profit in the project. The perspective is fully focussed on technical risks, which can affect profits greatly if they occur. It is therefore stated that the selection of the cues was connected to the interests of the respondent. A summary of this is given in table B40.

TABLE B40 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 20	Yes	●	◑	●

Reflection on the difference with the project manager

The respondent recognizes the selected cues of the project manager and respects the judgement, but indicates that difference is based on different primary responsibilities.

1.21. Analysis respondent 21

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B41.

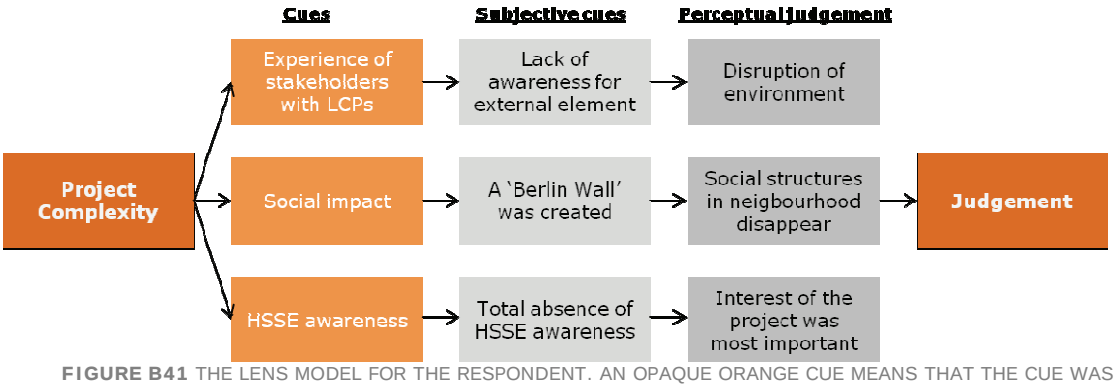


FIGURE B41 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues were chosen based on the bad relationship between the project team and external surroundings. The new project team reduced the judgement on the first and third element, the second element however cannot be resolved. The selected cues all translate into judgements that impact the project negative.
Furthermore, since the respondent did not mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies outside the circle of influence of the respondent.

The role of the respondent was the one of spokesman on behalf of the neighbourhood. All cues refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of economical and Russian. Since none of the cues refer to elements that come close to this education, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the neighbourhood. The perspective is fully focussed on the relation between the neighbourhood and the project. It is therefore stated that the selection of the cues was connected to the interests of the respondent. A summary of this is given in table B42.

TABLE B42 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 21	No	●	○	●

Reflection on the difference with the project manager

The respondent recognizes the selected cues of the project manager and shares his judgement on these cues.

1.22. Analysis respondent 23

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B43.

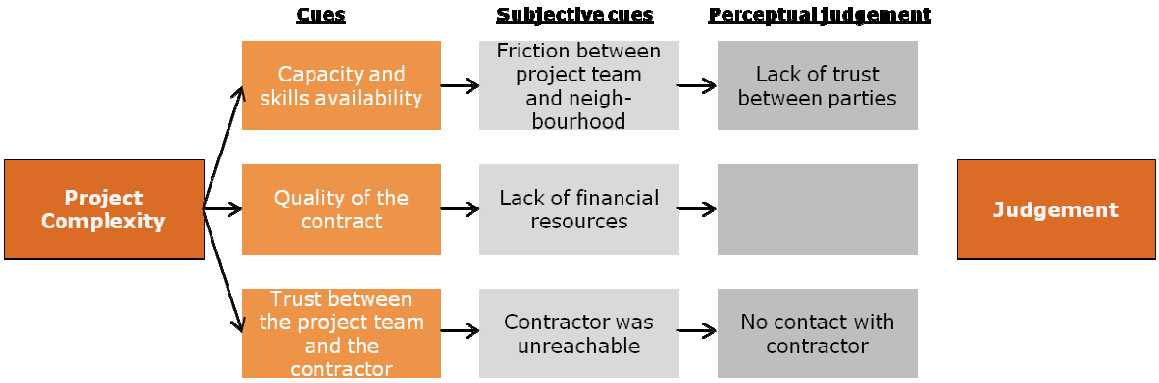


FIGURE B43 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues were chosen based on the bad relationship between the project team and external surroundings. The new project team reduced all elements with a new approach towards the external surroundings and a renewed contact with the contractor. All elements were explained as negative contributors to project result.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of chairman within the NGO. The first en third cues refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was partly connected to the role of the respondent.
The education of the respondent is of social psychology. Since none of the cues refer to elements that come close to this education, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the neighbourhood, translated into financial wishes. The perspective is fully focussed on the relation between the neighbourhood and the project, but not on the financial component. It is therefore stated that the selection of the cues was partly connected to the interests of the respondent. A summary of this is given in table B44.

TABLE B44 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 23	Yes	◑	○	◑

Reflection on the difference with the project manager

The respondent was not confronted with the differences of the project manager due to a lack of time during the interview.

1.23. Analysis respondent 24

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B45.

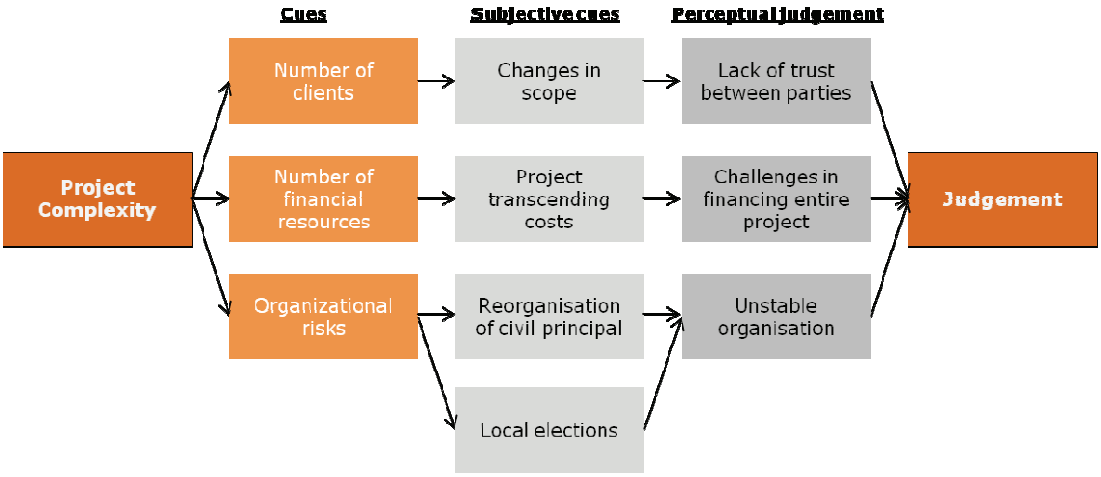


FIGURE B45 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues were chosen based on cues that refer to the civil principals. They are all based on problems within the project that impact the project performance negatively.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of project manager. All cues refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the rail infra manager, translated into a safe project in which the money is spent appropriate. The project is however more focussed on the organizational set-up of the project, but the cue of financial resources refers to appropriate spending of money. It is therefore stated that the selection of the cues was partly connected to the interests of the respondent. A summary of this is given in table B46.

TABLE B46 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 24	Yes	●	○	◑

1.24. Analysis respondent 25

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B47.

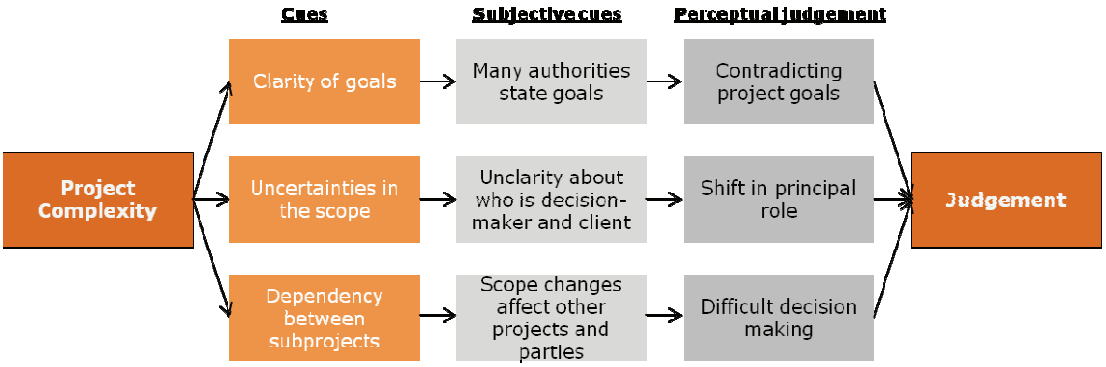


FIGURE B47 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues all refer to the process of scope definition. Although the cues are technical, the judgements all refer to organisational problems which impact the project negatively.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of project manager. All cues refer to judgements that refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is accounting. Since none of the cues refer to accounting, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the Secretary, thereby protecting the Secretary for politicians. The cues are all chosen because the respondent needs answers on the scope in order to satisfy the politicians. It is therefore stated that the selection of the cues was connected to the interests of the respondent. A summary of this is given in table B48.

TABLE B48 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 25	Yes	●	○	●

Reflection on the difference with the project manager

The respondent did not recognize the selected cues of the project manager since he believes that there is only one civil principal and only one finance source.

1.25. Analysis respondent 26

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B49.

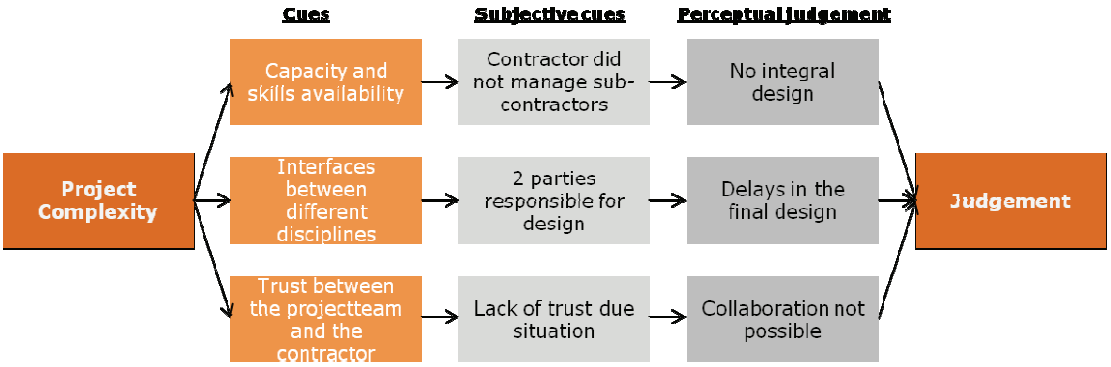


FIGURE B49 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues all refer to difficult relation with the contractor and the design process. Although all judgements refer to problems that have occurred, the respondent still sees the cues as valid. All cues translate into problems that impacted the project negatively.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of project director of the engineering firm. All cues refer to judgements that refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the project and challenges lie in the planning and execution of the project. The cues all result in judgements on this planning and execution. It is therefore stated that the selection of the cues was connected to the interests of the respondent. A summary of this is given in table B50.

TABLE B50 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 26	Yes	●	○	●

Reflection on the difference with the project manager

The respondent was not confronted with the differences since the survey answers were temporarily not available during the interview.

1.26. Analysis respondent 27

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B51.

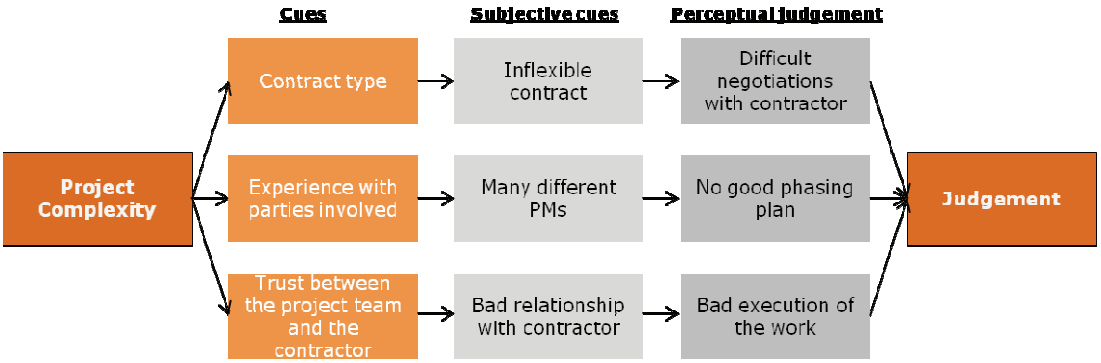


FIGURE B51 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The selected cues refer to the difficult relation between the project team and the contractor. The second cue refers to the prior project managers that were unable to make a sufficient phasing plan, and although the plan was of good quality at the moment of the interview, the respondent still considered the cue to be valid. All cues refer to judgements that have a negative impact on the project.
Furthermore, since the respondent did not mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies outside the circle of influence of the respondent.

The role of the respondent was the one of advisor on behalf of a rail carrier. No cues refer to judgements that refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was minimally connected to the role of the respondent.
The education respondent did not attend any specific education but has a large experience within different units of the rail carrier. Since none of the cues refer to this element, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the rail carrier asking for a future-proof infrastructure. The cues do not refer directly to this interest, but the respondent indicated that the terminated contract with the contractor was a chance to make a good future-proof design of the station. It is therefore stated that the selection of the cues was partly connected to the interests of the respondent. A summary of this is given in table B52.

TABLE B52 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 27	No	○	○	◑

Reflection on the difference with the project manager

The respondent did recognise the selected cues from the project manager, but indicated that the judgements were different since the two have different roles in the project.

1.27. Analysis respondent 28

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B53.

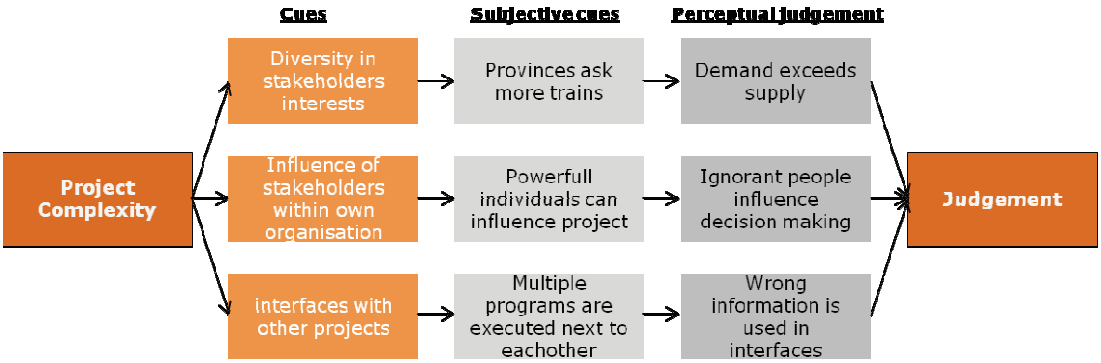


FIGURE B53 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The first cue forms the basic complexity in the assessment of the respondent, the second and third refer to the process to deal with the first cue. The first cue refers to a challenge the respondent faces, the last two to problems the respondent faces.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of program manager. All cues refer to judgements that refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education respondent is of both physical science and management science. Since none of the cues refer to this study directly and the respondent did not mention any reference to education, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the travellers translated into a solid infrastructure which can handle a high frequency of train movements. Only the first cue does refer directly to this interest. It is therefore stated that the selection of the cues was partly connected to the interests of the respondent. A summary of this is given in table B54.

TABLE B54 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 28	Yes	●	○	◑

Reflection on the difference with the project manager

The respondent did not recognise the cues of the project manager since she is not confronted with those three elements in her daily business.

1.28. Analysis respondent 29

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B55.

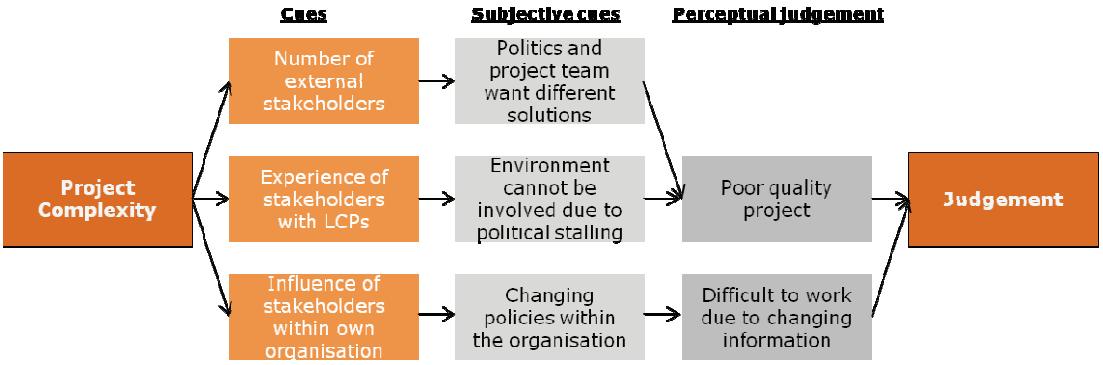


FIGURE B55 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The respondent mainly refers to the complexity created by the different perceived complexities of the civil principal and the project team, leading to a negative impact on the project. Changing policies also lead to a difficult working environment.
Furthermore, since the respondent did mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies within the circle of influence of the respondent.

The role of the respondent was the one of advisor program manager. All cues refer to judgements that refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of the project, translated into a smooth process which couples policy and design. All cues refer to the problems the respondent experiences when it comes to the policy. It is therefore stated that the selection of the cues was partly connected to the interests of the respondent. A summary of this is given in table B56.

TABLE B56 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 29	Yes	●	○	●

Reflection on the difference with the project manager

The respondent did recognise the first cue but does not share the judgement, recognises the second cue and agrees on it and indicated that different definitions formed the third difference but both mean the same thing.

1.29. Analysis respondent 30

With the data given in the interview, a descriptive lens model is constructed in order to grasp the perceived complexity of the respondent. This is shown in figure B57.

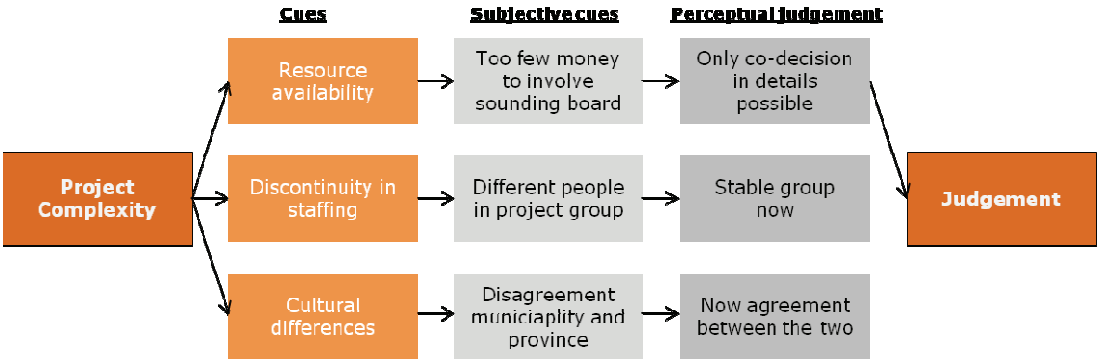


FIGURE B57 THE LENS MODEL FOR THE RESPONDENT. AN OPAQUE ORANGE CUE MEANS THAT THE CUE WAS NOT MENTIONED IN THE SURVEY BUT WAS MENTIONED IN THE IN-DEPTH INTERVIEW

Reflection on the perceived complexity

The last two cues referred to situations that are solved now. The first cue results in a judgement which is decreasing project complexity but also lowering the quality of the project.
Furthermore, since the respondent did not mention interventions to deal with the perceived complexity, it is noticed that the perceived complexity lies outside the circle of influence of the respondent.

The role of the respondent was the one sounding board member. All cues refer to judgements that refer to tasks that should be dealt with by this role. It is therefore stated that the selection of the cues was connected to the role of the respondent.
The education of the respondent is of a technical character. Since none of the cues refer to technical complexities, it is stated that the selection of the cues was minimally connected to the education of the respondent.
The interests the respondents indicated to embody are the interests of greenery around the station. The valid cue refers to the lack of decision making on project components that influence this interest. It is therefore stated that the selection of the cues was connected to the interests of the respondent. A summary of this is given in table B58.

TABLE B58 INFLUENCE OF THE RESPONDENT AND THE CONNECTION OF THE PERCEIVED COMPLEXITY TO THE ROLE, EDUCATION AND INTERESTS. AN EMPTY CIRCLE MEANS MINIMAL CONNECTION, AN HALF CIRCLE MEANS MEDIUM CONNECTION AND A FULL CIRCLE MEANS CONNECTION.

Data source	*Influence?*	*Connected to role*	*Connected to education*	*Connected to interests*
Respondent 30	No	●	○	●

Reflection on the difference with the project manager

The respondent did recognise the cues of the project manager but judged these cues differently due to a different vision: the respondent regarded the project from a political view, the project manager from a project view.

Appendix C. TOE-elements

The 57 elements of the TOE-framework that formed the basis of the survey are shown in table C1. They were used to obtain the perceived complexities of the respondents.

TABLE C1 57 TOE-ELEMENTS USED IN THE RESEARCH

#	*Element in Dutch*	*Element in English*
1	Onduidelijkheid over projectdoelstelling(en)	Clarity of goals
2	Aantal projectdoelstellingen	Number of goals
3	Incongruentie van projectdoelstellingen	Goal alignment
4	Onzekerheid over de scope	Uncertainties in the scope
5	Onzekerheid over technische methoden	Uncertainty in methods
6	Aantal deelprojecten	Number of subprojects
7	Diversiteit van deelprojecten	Diversity in subprojects
8	Afhankelijkheid tussen deelprojecten	Dependency between subprojects
9	Diversiteit van technische disciplines	Diversity in technical disciplines
10	Investeringskosten	Size in CAPEX
11	Projectduur	Project duration
12	Niveau van de kwaliteitseisen	Quality requirements
13	Gebruik nieuwe technologie	Newness of technology
14	Ervaring met toegepaste technieken	Experience with technology
15	Aantal locaties	Number of locations
16	Technische risico's	Technical risks
17	Aantal projectmedewerkers	Size of project team
18	Beschikbaarheid van capaciteit en vaardigheden	Capacity and skills availability
19	Beschikbaarheid van middelen	Resource availability
20	Discontinuïteit in bemensing	Discontinuity in staffing
21	Aantal opdrachtgevers	Number of clients
22	Aantal financieringsbronnen	Number of financial resources
23	Aantal uitvoeringscontracten en interfaces daartussen	Number of contracts and their interfaces
24	Contractvorm	Contract type
25	Kwaliteit van het hoofdcontract	Quality of the contract
26	Aansluiting tussen gebruikte projectmanagement tools en methodieken	Compatibility of different project management methods and tools
27	Ervaring met projectpartijen	Experience with parties involved
28	Samenwerking tussen aannemers	Collaboration between contractors
29	Interfaces tussen verschillende disciplines	Interfaces between different disciplines
30	Druk op de tijdsplanning	Time pressure
31	Werktijden	Working hours
32	Bereikbaarheid en bouwlogistiek	Accessibility and construction logistics
33	VGM-bewustzijn	Awareness on safety, health and environment
34	Aantal verschillende nationaliteiten	Number of different nationalities
35	Aantal verschillende talen	Differences between languages
36	Vertrouwen tussen projectteam en opdrachtgever	Trust between the project team and the client
37	Vertrouwen tussen projectteam en aannemer(s)	Trust between the project team and the contractor
38	Cultuurverschillen	Cultural differences
39	Organisatorische risico's	Organizational risks
40	Aard van de omgeving	Nature of the location
41	Aantal externe stakeholders	Number of external stakeholders
42	Diversiteit in belangen van externe stakeholders	Diversity in stakeholders interests
43	Afhankelijkheid van externe stakeholders	Dependencies on other stakeholders
44	Ervaring van omgevings-partijen met grote projecten	Experience of stakeholders with LCPs
45	Discontinuïteit bemensing stakeholders	Discontinuity in staffing of stakeholders
46	Invloed van stakeholders van binnen de organisatie	Influence of stakeholders within the internal organization
47	Managementsupport vanuit de eigen organisatie	Support of internal management
48	Sociale impact	Social impact
49	Politieke invloed	Political influence

50	Media invloed	Media influence
51	Economische omstandigheden	Economic climate
52	Marktomstandigheden	Market conditions
53	Planologisch/juridische procedures	Planning/juridical procedures
54	Conflicterende wet- en regelgeving	Conflicting legislation
55	BLVC-bewustzijn	HSSE awareness
56	Interfaces met andere projecten	interfaces with other projects
57	Externe risico's	Risks from environment

Appendix D. Justification of interventions and hypotheses

The tables below show justification for each hypothesis and each group of interventions as described in chapter six.

TABLE D1 ALLOCATION OF DIFFERENT INTERVIEW-PARTS TO THE DIFFERENT HYPOTHESIS OR SUB-PARTS OF THE HYPOTHESIS

Source	Interperation of intervention mentioned by respondent	Allocation
Respondent 19	The lack of control on the project is a source for perception: no control means complex.	I: control
Respondent 22	Control on the project is a source for perception: control means not complex.	I: control
Respondent 18	The allocation of risks is a source of perception: elements that cause risks cause a perception.	I: impact
Respondent 19	The perceived impact of project components is a source for perception.	I: impact
Respondent 21	The perceived impact of project components is a source for perception.	I: impact
Respondent 24	The allocation of risks is a source of perception: elements that cause risks cause a perception.	I: impact
Respondent 25	The perceived impact of project components is a source for perception.	I: impact
Respondent 27	The perceived impact of project components is a source for perception.	I: impact
Respondent 28	Components threatening to block the progress is a source of a perception	I: impact
Respondent 3	The components that cause problems in a project are sources.	I: impact
Respondent 30	The components that cause problems in a project are sources	I: impact
Respondent 5	Components of a project blocking the progress is a source of a perception	I: impact
Respondent 7	Components threatening to block the progress is a source of a perception	I: impact
Respondent 11	Occupation of time and energy by a component of the project is a source of perception.	I: mind
Respondent 12	Occupation of time and energy by a component of the project is a source of perception.	I: mind
Respondent 14	Occupation of attention is a source of perception.	I: mind
Respondent 16	Occupation of time and attention by a component of the project is a source of perception.	I: mind
Respondent 19	Occupation of attention is a source of perceptions.	I: mind
Respondent 2	Occupation of time and energy by a component of the project is a source of perception.	I: mind
Respondent 21	The occupation of time and energy is a source.	I: mind
Respondent 24	The allocation of time and attention is a source.	I: mind
Respondent 27	The allocation of attention is a source.	I: mind
Respondent 28	Allocation of time and attention is a source.	I: mind
Respondent 3	Occupation of time and energy by a component of the project is a source of perception.	I: mind
Respondent 5	Occupation of time and energy by a component of the project is a source of perception	I: mind
Respondent 6	Occupation of time and energy by a component of the project is a source of perception	I: mind
Respondent 7	Perceptions are based on the financial component of the project	III: capex
Respondent 24	Perceptions are based on the environment.	III: environment
Respondent 7	Perceptions are based on the geographical position with respect to the centre of political power	III: geography
Respondent 26	Perceptions are based on the geographical position with respect to the centre of political power	III: geography
Respondent 25	Perceived differences in project phase lead to differences	III: phase
Respondent 1	Different scales of the scope leads to different perceptions	III: scope
Respondent 24	Perceptions are based on the type of project.	III: type
Respondent 7	Perceptions are based on the type of project	III: type
Respondent 1	Interests, education and experiences within other projects are sources for a perception.	IV: interests
Respondent 20	The interests which the individual represents is a source for perceptions.	IV: interests
Respondent 21	The interests which the individual represents is a source for perceptions.	IV: interests
Respondent 29	The interests which the individual represents is a source for perceptions.	IV: interests
Respondent 1	Different stakes lead to different perceptions	IV: interests
Respondent 4	Different interests lead to different perceptions	IV: interests
Respondent 8	The different interests lead to different perceptions	IV: interests

Respondent 11	The different interests lead to different perceptions	IV: interests
Respondent 14	Different interests lead to differences.	IV: interests
Respondent 15	Different interests lead to differences.	IV: interests
Respondent 22	Different interests lead to differences.	IV: interests
Respondent 25	Different interests lead to differences	IV: interests
Respondent 29	Differences in interests lead to differences	IV: interests
Respondent 30	Differences in interests lead to differences	IV: interests
Respondent 13	The different attitudes of stakeholders lead to different perceptions: company/organization interest or project interest?	IV: interests; company/ project
Respondent 2	Personal mission is a source for perception.	IV: mission
Respondent 8	Personal mission is a source of a perception	IV: mission
Respondent 9	Company mission is a source of perception	IV: mission
Respondent 2	Different opinions on the effects of the market lead to different perceptions	IV: mission
Respondent 10	Role is a source of a perception	IV: role
Respondent 15	The role (of architect) is a source of perception	IV: role
Respondent 29	The role is a source of perception	IV: role
Respondent 1	Technical roles focus on technical complexities	IV: role
Respondent 7	Different roles lead to different perceptions	IV: role
Respondent 16	Different positions within the organisational structure lead to differences	IV: role
Respondent 18	Different roles lead to different perceptions	IV: role
Respondent 20	The different responsibilities of actors lead to differences	IV: role
Respondent 22	Different affections on the role lead to differences.	IV: role
Respondent 28	Differences in roles lead to differences.	IV: role
Respondent 30	Differences in roles lead to differences.	IV: role
Respondent 4	The difference between designers and contractors lead to different perceptions	IV: role; designers/ contractors
Respondent 8	The difference between engineers and others lead to different perceptions	IV: role; engineers/ others
Respondent 4	The difference between public parties and private parties lead to different perceptions	IV: role; public/private
Respondent 8	The difference between public parties and private parties lead to different perceptions	IV: role; public/private
Respondent 20	The difference between public parties and private parties lead to different perceptions	IV: role; public/private
Respondent 4	Experiences within other projects is a source for a perception	II
Respondent 7	Experience, from the person or from others, is a source of a perception	II
Respondent 10	Experience is a source of a perception: more experience leads to less complex perception	II
Respondent 16	Experience (on the same project) is a source of perception: more experience means less complex.	II
Respondent 27	Experience is a source of perception.	II
Respondent 23	Available information leads to a perception.	V: Info
Respondent 3	A lack of understanding the techniques and processes needed to realize these techniques lead to different perceptions	V: Info
Respondent 3	Differences in available knowledge lead to different perceptions	V: Info
Respondent 8	The difference in knowledge and information on a project lead to different perceptions	V: Info
Respondent 9	The difference in technical knowledge lead to different perceptions	V: Info
Respondent 10	The difference in knowledge and information on a project lead to different perceptions	V: Info
Respondent 11	The difference in knowledge and information on a project lead to different perceptions	V: Info
Respondent 20	Differences in informational insight lead to different perceptions	V: Info
Respondent 26	Differences in information lead to differences.	V: Info
Respondent 27	Differences in information lead to differences.	V: Info
Respondent 4	Differences are natural and no problem if all actors can deal with these differences	VI
Respondent 6	Different perceptions are a negative phenomenon	VI
Respondent 10	People must have the same image of the project	VI
Respondent 12	Differences need to be managed and perceptions need to be exchanged if there is a chance that the difference cause harm to the project	VI
Respondent 15	Differences need to be managed and perceptions need to be exchanged in order to look in the same direction.	VI
Respondent 16	Interests need to be exchanged in order to create understanding and skip the conflict phase	VI
Respondent 17	Interests need to be exchanged; contrasting interests could cause differences.	VI
Respondent 21	Differences need to be managed and perceptions need to be exchanged in order to reach agreement on crucial project elements.	VI
Respondent 24	Perceptions are an undesirable phenomenon which impact project performance negatively: one vision contributes positively to project performance	VI
Respondent 27	Differences need to be managed and perceptions need to be exchanged in order to avoid problems in the project.	VI
Respondent 28	Differences need to be managed and perceptions need to be exchanged in order to come to a jointly goal	VI
Respondent 30	Differences need to be managed and perceptions need to be exchanged in order to create understanding.	VI
Respondent 1	Differences lead to restlessness which leads to a more complex project	VI

Respondent 3	Differences lead to promises which cannot be met	VI
Respondent 3	Differences manifest subcutaneous and lead to incomprehension and irritations	VI
Respondent 4	Differences lead to biased information	VI
Respondent 4	Differences lead to strategic advantage positions which lead to unwillingness to exchange information	VI
Respondent 4	Differences lead to strategically advantages for some parties.	VI
Respondent 6	Differences lead to poor project performance	VI
Respondent 6	A lack of uniformity lead to poor project performance because the process is not well managed	VI
Respondent 6	Differences contribute negatively to the project performance.	VI
Respondent 7	Differences lead to inadequate staffing if the complexity is misunderstood	VI
Respondent 7	Differences lead to lack of management attention when the complexity is misunderstood	VI
Respondent 9	Differences cause contractual risks when it comes to the environment and contact with the contractor	VI
Respondent 12	Differences can lead to poor project performance	VI
Respondent 23	A better understanding of project complexity works in explaining the project to the followers of the internal organisation	VI
Respondent 24	Differences between the project team and the civil principal lead to different understanding of the project.	VI
Respondent 26	Differences led to oversimplified contracts which led to poor project performance	VI
Respondent 27	Differences lead to problems in projects.	VI
Respondent 29	Different perceptions between the project team and the civil principal lead to complications in the execution of projects.	VI
Respondent 29	Different perceptions are important to understand the external stakeholders.	VI
Respondent 30	Different perceptions lead to different allocations of attention	VI
Respondent 7	Differences contribute positively to the project performance because you need the ability to look from the other side to the project	VII
Respondent 9	Differences need to be managed and perceptions need to be exchanged in order to understand the project.	VII
Respondent 11	Differences need to be managed and perceptions need to be exchanged in order to understand the system.	VII
Respondent 13	Differences need to be managed and perceptions need to be exchanged in order to understand the problems.	VII
Respondent 18	Differences need to be managed and perceptions need to be exchanged in order to understand the risks.	VII
Respondent 19	Differences need to be managed and perceptions need to be exchanged in order to create a richer picture of reality.	VII
Respondent 19	Differences are a desirable phenomenon.	VII
Respondent 26	Differences need to be managed and perceptions need to be exchanged in order to understand the system.	VII
Respondent 26	Differences are a desirable phenomenon.	VII
Respondent 11	Differences lead to conversations which lead to better understanding the system	VII
Respondent 14	A better understanding of project complexity works in explaining the project to the followers of the internal organisation	VII
Respondent 18	Differences in perceptions lead to differences in awareness of project complexity	VII
Respondent 25	Differences lead to a better understanding of the project	VII

TABLE D2 ALLOCATION OF DIFFERENT INTERVENTIONS MENTIONED BY RESPONDENTS WITHIN THE FRAMEWORK OF INTERVETIONS

Source	Intervention	Classification
Respondent 25	Use second opinions to verify perceptions	Controlling
Respondent 2	Create independency: organize the project delivery team in a project bureau	Controlling
Respondent 27	Internal supervision within the same organisation is important	Controlling
Respondent 2	Coaching of experienced people for the project delivery team	Controlling
Respondent 2	Replace people that block the progress of the project	Controlling
Respondent 25	Judge design scenarios	Controlling
Respondent 5	Do not involve more people: they make the project more complex	Connecting
Respondent 25	Create a workspace where parties are physically present	Connecting
Respondent 2	Ask the questions behind questions	Connecting
Respondent 25	Ask open questions	Connecting
Respondent 27	Create trust by attending informal activities.	Connecting
Respondent 25	Create trust by organising activities where people share visions	Connecting
Respondent 2	Use interpreters to transfer perceptions without hierarchical noise	Connecting
Respondent 25	Create a desk that functions as interpreter between parties	Connecting
Respondent 2	People are crucial in the project performance	
Respondent 27	The project team make the difference.	
Respondent 27	Experiences of the project team with the same type of project is important.	
Respondent 27	Put pressure on the project through superiors	Actuating
Respondent 28	Choose a lead-and-follow-approach or a consensus-approach based on the situation.	Actuating
Respondent 2	Create ownership: introduce a meeting of all clients and sponsors	Actuating
Respondent 25	Important civil principals must actively claim client ship of the project	Actuating
Respondent 5	Enforce decisions: escalate the problem to superiors	Actuating
Respondent 25	Make sure that all stakeholders keep talking to each other	Controlling
Respondent 28	Separate the person leading the process from the person defending interests.	Controlling
Respondent 5	Prepare decisions between lower levels between organizations	Controlling
Respondent 28	Make time: disconnect the critical path from the rest of the project	Controlling

Respondent 2	Surround yourself with people that complement your own perception	Connecting
Respondent 28	Involve the right people in decision making	Connecting
Respondent 2	Be open and transparent	Connecting
Respondent 28	Create awareness of the problem in the internal organisation	Connecting
Respondent 28	Create understanding for the reality of other people	Connecting
Respondent 28	Share starting points and changes actively with interfacing projects.	Connecting
Respondent 17	People need to focus on the interest of the project instead of the interest of the company.	Actuating
Respondent 17	People need to think win-win, not win-lose.	Actuating
Respondent 20	Mirror the organisation of the project team to the organisation of the contractor	Controlling
Respondent 12	The project team has to make sure that all stakeholders are on the same knowledge level	Controlling
Respondent 20	Do not shift all responsibilities to the contractor but show yourself a mature principal.	Controlling
Respondent 12	Independent parties can settle differences	Connecting
Respondent 16	Conflicts need to be separated from the process by reaching 'agree to disagree'. Other techniques must be found to solve these problems.	Connecting
Respondent 17	Create a workspace where people fysically work together	Connecting
Respondent 12	Communicate open and fair	Connecting
Respondent 20	The PT must make the first step in a good collaboration and the contractor must follow; this creates a relationship.	Connecting
Respondent 12	Organise a PSU and sequels to this meeting.	Connecting
Respondent 16	Arrange a PSU with informal contact moments in which both project team and contractor participate	Connecting
Respondent 20	Arrange a PSU which focuses on the exchange of visions.	Connecting
Respondent 16	Share interests and agree to disagree	Connecting
Respondent 20	Understand the interests of other people.	Connecting
Respondent 17	Design a consultation structure	Connecting
Respondent 12	Trust between parties is of high importance	
Respondent 20	People need to work together for a long time in order to come to a good collaboration.	
Respondent 12	Organise 1-on-1 meetings between counterparts	Actuating
Respondent 17	People must be prepared to be the devil´s advocate in the internal organisation.	Actuating
Respondent 17	Environmental managers need to earn space within the project team.	Controlling
Respondent 12	Conduct interface-meetings and use systems engineering to execute decisions	Controlling
Respondent 17	Introduce an interface meeting	Controlling
Respondent 16	Parties must be willing to fire employees on the project if they resist the project management style.	Controlling
Respondent 20	Find the right people within scientific institutes or pensioned colleagues	Controlling
Respondent 12	Stress collaboration between sub-contractors	Controlling
Respondent 16	Combining the DBMO in a DMFMO contract intro one organisation reduces complexity.	Controlling
Respondent 17	Managing the relations between disciplines is managing complexity.	Controlling
Respondent 12	Make time: construct project parts at the same time in stead of sequential	Controlling
Respondent 17	Apply systems engineering, verificate and validate	Controlling
Respondent 16	Make time: construct project parts at the same time in stead of sequential	Controlling
Respondent 17	Continuity of people is important in LCPs	
Respondent 12	Repair the conservative view that contractors always want to bill additional work.	
Respondent 16	Communicatie transparant about the delivery deadline to all project employees	
Respondent 17	The new constructor does not construct, but delivers a service of which construction is one part. Environmental management is essential.	
Respondent 11	Enforce participation by juridical steps	Actuating
Respondent 23	Actively use your network of people to get things done.	Actuating
Respondent 11	Activate interpreters that can explain the complexity, preferably within the organisation of the counterpart through an informal network	Actuating
Respondent 21	The result towards the environment must be centralised in project management	Controlling
Respondent 23	Turn the responsibility for the burden of proof.	Controlling
Respondent 21	Seperate the roles in the project team so that the interests can be accounted for	Controlling
Respondent 11	Explain with the help of photos and pictures	Controlling
Respondent 11	Make sure that all stakeholders are at the same knowledge level	Controlling
Respondent 21	Mind about the working hours with respect to the environment	Controlling
Respondent 30	Make financing an important part in the preparation phase in order to manage expectations	Controlling
Respondent 23	Change the people working on a project	Controlling
Respondent 21	Do not shift all responsibilities to the contractor but show yourself a mature principal; bad environmental is eventually for the cost of the governmental agencies.	Controlling
Respondent 23	Money and risk awareness reduce complexity.	Controlling
Respondent 23	Build goodwill in the environment	Connecting
Respondent 30	Involve the environment early in the process	Connecting
Respondent 23	The project must show construction decency in order to strengthen collaboration between the project en the environment.	Connecting
Respondent 21	Perceptions of neighbours need to be taken into account. The compensation desk is important.	Connecting
Respondent 23	Show empathy for other complexities	Connecting
Respondent 11	Listen to each other	Connecting

Respondent 23	Create trust without mitigating arguments by communicating about differences in experiences	Connecting
Respondent 23	Prepare meetings in an informal meeting before entering the formal meeting	Connecting
Respondent 14	Organise interface meetings	Controlling
Respondent 14	Create space to obey the interests of others by being flexible in the rules.	Connecting
Respondent 14	Kind people can make a difference in management	Connecting
Respondent 14	Represent the perceptions of others within the own organisation.	Actuating
Respondent 14	Find juridical loopholes to ensure project progress	Actuating
Respondent 30	Use perceptions as a strategic tool	Actuating
Respondent 21	Focus attention on the circle of influence	Controlling
Respondent 14	Physical presence makes a difference when communicating with parties	Connecting
Respondent 14	Force yourself to keep conversations going	Connecting
Respondent 21	The preparation phase is crucial; civil principals must balance preparations and dare to not execute a project	
Respondent 23	Constructors must have fun in their work	
Respondent 24	Use informal networks to get things done within the own organisation	Actuating
Respondent 18	Explain complexity of others in the own organisation	Actuating
Respondent 1	PTs must be pro-active in solving issues by initiating solutions to civil principals	Actuating
Respondent 18	Off the record: Claim space within the civil principal by making a fist on the table	Actuating
Respondent 24	Let important financiers co-sign important decisions to create awareness.	Actuating
Respondent 3	Inform: escalate the problem to superiors	Actuating
Respondent 24	A separate project bureau leads to more independency and more freedom to manage complexity.	Controlling
Respondent 24	Inform people by explaining the project and its complexities in a good story.	Controlling
Respondent 4	Make detailled designs as early as possible	Controlling
Respondent 29	Civil principals must make decisions on time in order to leave space for an open and transparent attitude in the environment	Controlling
Respondent 29	Money can manage complexity.	Controlling
Respondent 18	Enough time and money results in a good project.	Controlling
Respondent 15	Share and communicate perceptions in order to achieve an integral design	Connecting
Respondent 24	Create trust and awareness with project parties.	Connecting
Respondent 18	Explain complexity of others in the own organisation	Connecting
Respondent 24	Create a tool to explain the complexity	Connecting
Respondent 8	Enable powerfull actors to empower your statement towards a party	Actuating
Respondent 13	The right actors need to solve the right issues, because different statuses of parties can make a difference	Actuating
Respondent 8	Public and private interests must be balanced within a project. Therefore the government has to stay involved in decision making: total outsourcing cannot be done	Actuating
Respondent 13	Escalate decisions if no consensus can be reached	Actuating
Respondent 18	Fix the remuneration in order to focus on quality.	Controlling
Respondent 18	Listen closely to each other during the dialogues to prevent a false dialogue	Controlling
Respondent 15	Create a clear and unambiguous core of the project that people can use to express their perceptions	Controlling
Respondent 26	Reconsider D&C contracts, consider traditional contracts	Controlling
Respondent 15	Formulate clear contractural criteria with controlable paramters	Controlling
Respondent 26	Introduce interface meetings	Controlling
Respondent 9	Conduct audits	Controlling
Respondent 22	The contractor must participate in environmental communication.	Controlling
Respondent 26	Contractors must provide the service of integral design leader.	Controlling
Respondent 26	Principals must show a professional attitude by managing expectations.	Controlling
Respondent 15	Ask for detailled designs in the dialogue phase in order to ensure contact between consortium and architect	Controlling
Respondent 26	Demand an integral design of the contractor	Controlling
Respondent 8	Public parties have to end contracts with private parties if these parties do not do a good job: parties do not need to feel convicted to each other.	Controlling
Respondent 18	Create an informal and good atmosphere during the dialogue phase. This triggers creative and contributes to collaboration.	Connecting
Respondent 13	Create trust between parties in the tendering phase.	Connecting
Respondent 24	Off the record: Physical presence makes a difference when communicating with parties	Connecting
Respondent 7	Improve communication by putting the actors physically into one working space.	Connecting
Respondent 13	Continuity of people is important in order to build relationships	Connecting
Respondent 13	Putting yourself in a vulnerable position and keeping yourself there beyond your comfort zone is the first step in creating trust. Apply pressure on the counterpart if they do not follow you in that movement.	Connecting
Respondent 7	PTs must seek collaboration with the constructor, no top-down assignment	Connecting
Respondent 15	The tender-phase is of high-importance: bad tendering results in a bad collaboration.	Connecting
Respondent 26	Arrange a PSU with corresponding follow-ups in order to verify perceptions	Connecting
Respondent 29	Seperate the person leading the process from the person defending interests.	Actuating
Respondent 4	Create an informal external network	Actuating
Respondent 22	Let the environment co-design details of solutions.	Actuating
Respondent 29	Let the environment co-design in the plan.	Actuating
Respondent 13	Enforce decision making with the help of powerful project parties	Actuating
Respondent 8	There must be clear communication, therefore every decision has to be carefully prepared and well motivated. If something cannot be done, the limits of cooperation have to be indicated.	Controlling

Respondent 22	Interests of the environment must be treated equally important to the interests of construction.	Controlling
Respondent 10	Translate important environmental interests into contractual criteria	Controlling
Respondent 19	Communicatie transparant about compensation possibilities	Controlling
Respondent 10	Communicate the important issues and how they are handled clearly to the external stakeholders.	Controlling
Respondent 7	Be open and transparant towards the environment. Manage the expectations.	Controlling
Respondent 7	Give confidence by basing actions on knowledge	Controlling
Respondent 29	Inventise demands objectively	Controlling
Respondent 4	Do not adapt an external strategy purely on meetings with external stakeholders: they are not representative for all stakeholders	Controlling
Respondent 6	Communication: organize meetings with adjacent projects	Controlling
Respondent 24	Communicate and involve people early in the process.	Connecting
Respondent 22	Steer on listening and understanding. Not on consensus.	Connecting
Respondent 22	Do not inform the environment but seek interaction.	Connecting
Respondent 22	Be open and transparent. Show a vulnerable position.	Connecting
Respondent 19	Do not focus on the technical components in a story	Connecting
Respondent 19	Let the practitioners explain the project to the environment.	Connecting
Respondent 22	Joint Fact Finding with the neighbourhood.	Connecting
Respondent 10	Conduct different types of conversations and plan them in logical orders	Connecting
Respondent 24	The project manager must not apply the all-knowing style but stimulate actors to discover the project	Actuating
Respondent 8	Enforce others to listen to complexity views, if necessary through superiors	Actuating
Respondent 1	Create the right knowledge and information	Actuating
Respondent 6	Create the right knowledge for the project delivery team	Actuating
Respondent 7	Exchange all new information within the project team as much as possible	Actuating
Respondent 19	Replace people if there is too much alignment in the team	Controlling
Respondent 13	Do not focus on time, scope and money. They are the expressions of problems, not the sources.	Controlling
Respondent 19	Do not focus on time, scope and money. They are the expressions of problems, not the sources.	Controlling
Respondent 3	Create a clear project delivery team which is responsible for the project	Controlling
Respondent 6	Reduce differences by providing everybody with the same information. Steer on unambiguous.	Controlling
Respondent 1	Internal network: keep in close touch with line-management	Controlling
Respondent 1	Increase redundancy: point out assistents for every actor in the IPM model	Controlling
Respondent 18	Overcome internal lack of skills by involving market knowledge	Controlling
Respondent 13	Consult project parties before entering negotiations	Controlling
Respondent 15	Content experts must claim time with project management	Controlling
Respondent 13	Make time: construct project parts at the same time in stead of sequential	Controlling
Respondent 18	Do not apply interface management since it costs too much work to put interfaces back together.	Controlling
Respondent 26	De-bundle, de-phase and de-compose a project if it cannot be explained anymore.	Controlling
Respondent 10	Apply an integral approach of the assignment	Controlling
Respondent 19	Focus on perceptions, not on "truth". Perceptions are the reality.	Connecting
Respondent 19	Do not focus on tools, focus on people and their skills.	Connecting
Respondent 26	People make the difference: they must handle complexity together, not fight each other.	Connecting
Respondent 19	Correspond your desired image with your project management style by cultivating a culture by example behaviour, centring values and creating a culture.	Connecting
Respondent 26	Physical presence makes a difference when communicating with parties	Connecting
Respondent 3	Create a physical workspace, thereby enhancing contact between project deliver team members	Connecting
Respondent 1	Listen to what is meant, not to what is said	Connecting
Respondent 13	Read the question behind the question	Connecting
Respondent 18	Verify the meaning behind words of one another	Connecting
Respondent 26	Create understanding by asking the question behind the question	Connecting
Respondent 10	Explain the complexity to others	Connecting
Respondent 9	Ask open questions and provide answers with examples. Concentrate on the facts	Connecting
Respondent 19	Ask truly open questions in meetings so that visions become clear	Connecting
Respondent 19	Steer on understanding, not on agreement	Connecting
Respondent 19	Create understanding on the responsibility of one person into the bigger picture.	Connecting
Respondent 1	Communication between actors: organize meetings and ask critical questions	Connecting
Respondent 15	Collaboration. People make the difference. People need to be ambitious, happy, trustful, show courage and be transparent.	Connecting
Respondent 15	People must be willing to act between the rules protocols.	Connecting
Respondent 19	People need to have fun and like working on the project.	Connecting
Respondent 26	People must have fun in their job in order to manage complexity.	Connecting
Respondent 18	Staff the right people in the right phase: a dialogue phase asks for different types of people then the execution phase.	Connecting
Respondent 8	Make use of experts on different topics	Connecting
Respondent 19	Managing the relations between disciplines is managing complexity.	Connecting
Respondent 24	Managing the relations between disciplines is managing complexity.	Connecting
Respondent 1	People are crucial in the project performance	

Respondent 26	Interests of the project must be centralised in project management, not company interests
Respondent 19	Combine both hard en soft approaches into one management style
Respondent 24	Look for uncomfortable people in meetings
Respondent 24	Do not split project- en process management. They happen at the same time.
Respondent 29	Mix soft project management with hard management.