Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

How to scale up proven product innovations in road construction projects of Rijkswaterstaat?

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‘*The more demanding the innovation challenges like poverty, ill health or environmental damage, the greater becomes the importance of effective policy. This is not a question of “picking winners”—an uncertainty-shrouded dilemma which is anyhow equally shared between public, private and third sectors. Instead, it is about engaging widely across society, in order to build the most fruitful conditions for deciding what “winning” even means’*.

Stirling (2014, p.2)

Colophon

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Preface

Before you lies my master thesis of the study Business Administration with specialisation Innovation & Entrepreneurship of the University of Twente. After finishing my bachelor Business Engineering I wanted to gain more scientific knowledge towards innovation and how organizations are dealing with it. It has been a rollercoaster with a lot of personal- and professional developments along the way but at the end it I can happily say it have made me wiser, self-confident and even more enthusiastic about innovations.
Innovations are becoming a necessity for a lot of companies to stay competitive and for the government to achieve societal goals in a faster pace. With different perceptions towards a product innovation of each person involved it is really a social matter before it becomes a technical or organizational matter. I believe Rijkswaterstaat is showing that they are willing to buy innovations and they will do even more in the future. I hope my thesis has given them a better understanding on how they can influence the upscaling of proven product innovations in large road construction projects. I want to thank my supervisors from Rijkswaterstaat, Gijsbert de Jong and Arnoud de Bruijne, for their time, patience and knowledge during the whole process. Furthermore I want to thank my 1st examiner prof. dr. Jan Telgen for his guidance and support and also my 2nd examiner prof. dr. ir. Andree G. Dorée for his time and feedback. I hope the road construction industry will keep developing and implementing product innovations to create a more sustainable, safe and liveable road infrastructure for us and for the next generations to come.

Summary

This research was formulated due to the observation of Rijkswaterstaat (RWS) that there is a lack of upscaling of proven product innovations which are often only applied once. The main research question was how RWS could influence the upscaling of proven product innovations in large road construction projects in the Netherlands. Qualitative desk research was done to describe a theoretical framework related to the factors influencing the upscaling of product innovations. Looking more into the road construction industry, the contractors and RWS the theoretical framework was used to get a good understanding on which factors were most influential where RWS could focus on. Interviews with 9 contractors and the relationship with the antecedents and instruments which RWS uses to scale up product innovations resulted in several influential conclusions and recommendations.

Whereas an innovation can be perceived differently it is important to know what factors are influential. In order to scale up a product innovation it should be embedded as a dominant design, meet performance- and reliability requirements and meet consumers' demands for a broad range of projects. It was seen that contractors often develop innovations (with partners) for themselves due to several reasons which prevented diffusion and upscaling to take place. A lack of clear market potential was one of the main reasons which made it hard to diffuse or adopt a product innovation. It means that the innovation-decision process of other contractors often stopped at the knowledge stage. A clear policy with smart goals in future projects should be described in order to increase the willingness of contractors to diffuse and/or implement product innovations. Together with provinces and municipalities they can increase the upscaling potential of product innovations when they create overarching goals and define what added value is desired and how they will be rewarded in future projects. It can increase the diffusion and upscaling of product innovations between SME's and large contractors. Another important barrier which was described is the fact that tenders often doesn't give space for product innovations to be applied (again). Regulations and legislations were often not changed during the tendering process. In order to make space RWS should gather data of proven product innovations in projects together with the costs and benefits as an input for writing the tender. In that way they know which product innovations can contribute to the scope and goals of the project and where they have to make space. They can also formulate MEAT-criteria which make a distinctive outcome between contractors. Clears standards should be described for each MEAT-criteria in order for contractors to measure product innovations on forehand stimulating the diffusion and upscaling process. RWS can stimulate upscaling by asking directly or indirectly for innovation in tenders. Directly via standardization which increases the upscaling of certain products but decreases the potential of other new product innovations being implemented. Indirectly they can ask for added value which could be achieved by applying product innovations which can be awarded via MEAT-criteria. Specifications and the type of tender can also make space for product innovations and stimulate contractors to adopt and apply them in future tenders. Pressure and policy from the ministry of I&E and RWS can be helpful together with programs set up by RWS to steer developments and the implementation of certain types of product innovations by contractors. Currently most contractors don't have their own innovation strategy due to a lot of the described uncertainties for applying a product innovations. Knowledge creation and -sharing should be stimulated by RWS within the market towards several topics and products (or CoPS) in order to describe clear and realistic goals for future projects. They should communicate and discuss with the market what the desired needs and requirements for a broad range of projects will be and how to deal with the potential risks and consequences. The involvement of the procurement department in an early stage and a systematic learning approach between projects should be helpful in order to continually improve and stimulate the upscaling of product innovations to achieve the desired goals.

Samenvatting

Dit onderzoek is geformuleerd n.a.v. een observatie door Rijkswaterstaat (RWS) dat er een gebrek is aan het opschalen van bewezen productinnovaties die vaak maar eenmalig worden toegepast. De onderzoeksvraag voor het onderzoek is hoe RWS het opschalen van bewezen productinnovaties in grote wegenbouwprojecten in Nederland kan beïnvloeden. Kwalitatief onderzoek is uitgevoerd om een theoretisch kader te beschrijven met betrekking tot het beïnvloeden van het opschalen van productinnovaties. De wegenbouwindustrie, de aannemers en RWS zijn beschreven op basis van het theoretisch kader om te begrijpen waar RWS zich op zou kunnen concentreren. Interviews met 9 aannemers en de relatie met de middelen en instrumenten die RWS gebruikt om productinnovaties op te schalen resulteerde in verschillende belangrijke conclusies en aanbevelingen.
Daar waar een innovatie verschillend kan worden ervaren is het belangrijk om te weten welke factoren van invloed zijn. Om op te kunnen schalen zal een productinnovatie moeten worden ingebed als een dominant ontwerp, moet het voldoen aan prestatie- en betrouwbaarheidseisen en zal het moeten voldoen aan de wensen van de klant voor een breed scala aan projecten. Vanuit de aannemers is gebleken dat ze vaak innovaties enkel voor zichzelf ontwikkelen (al dan niet met partners) wat de verspreiding en het opschalen van een innovatie belemmerd. Een gebrek aan duidelijkheid omtrent het marktpotentieel is één van de redenen wat het lastig maakt om een innovatie te verspreiden en toe te passen. De innovatiebeslissingsproces van andere aannemers stopt dan ook meestal in het kennisstadium. Een duidelijk beleid met smart beschreven doelen voor toekomstige projecten zou dan ook uitkomst bieden om de bereidheid van aannemers te vergroten om productinnovaties te verspreiden en toe te passen. RWS kan samen met provincies en gemeenten het opschalingspotentieel vergroten door overkoepelende doelstellingen te formuleren waarbij de toegevoegde waarde is beschreven en hoe deze zal worden beloond. Het zal de verspreiding van productinnovaties tussen kleine- en middelgrote aannemers met de grote aannemers kunnen bevorderen. Een belangrijke belemmering voor aannemers is het feit dat aanbestedingen vaak geen ruimte bieden voor productinnovaties om (nogmaals) toegepast te worden. Wet- en regelgeving worden vaak niet aangepast tijdens het inschrijvingsproces. Om ruimte te maken kan RWS data van bewezen productinnovaties verzamelen samen met de kosten en baten als input voor het schrijven van tenders. Op die manier kan achterhaald worden welke productinnovaties kunnen bijdragen aan het behalen van de scope en doelstelling en voor welke producten er ruimte gemaakt dient te worden. Tevens kunnen ze EMVI-criteria formuleren die onderscheidend zijn tussen aannemers. Voor elke criteria dient ook een standaard beschreven te worden voor aannemers om de uitkomst ervan op voorhand te kunnen meten wat de verspreiding en opschaling kan bevorderen. RWS kan innovaties direct of indirect uitvragen. Direct via standaardisatie en indirect door toegevoegde waarde te vragen welke behaald kan worden door productinnovaties toe te passen welke kunnen worden beloond in EMVI-criteria. Specificaties en het type aanbesteding kunnen ook ruimte maken voor productinnovaties en kunnen aannemers stimuleren om ze te adopteren en toe te passen in toekomstige projecten. Beleid en druk vanuit het ministerie I&M en RWS plus opgezette programma's kunnen zorgen dat bepaalde soorten productinnovaties worden ontwikkeld en toegepast door aannemers. De meeste aannemers hebben geen innovatiestrategie dankzij de beschreven onzekerheid omtrent het kunnen toepassen van innovaties. Kenniscreatie en -deling dienen gestimuleerd te worden door RWS binnen de markt omtrent verschillende onderwerp en producten (CoPS) om zo realistische doelen voor toekomstige projecten te kunnen beschrijven. Communicatie en discussie met de markt is van belang om de gewenste behoeften en vereisten te bespreken voor een breed scala aan projecten en hoe ze met de mogelijke risico’s en gevolgen kunnen omgaan. Het betrekken van de inkoopafdeling in een vroeg stadium en het op een systematische manier leren tussen projecten is noodzakelijk om continu te verbeteren en om het opschalen van productinnovaties te stimuleren met als doel de gewenste doelstellingen te bereiken.

List of figures

List of tables

Abbreviations

CIS	Corporate Innovation Strategy, part of Rijkswaterstaat
CoPS	Complex Products and Systems
EU	European Union
GDP	Gross Domestic Product
GPO	Large projects and maintenance (in Dutch: Grote Projecten en Onderhoud)
GWW	Civil engineering industry (in Dutch: Grond-, weg-, en waterbouw).
ICT	Information and Communication Technologies
I&E	Ministry of Infrastructure and Environment (in Dutch: Infrastructuur & Milieu)
km	Kilometre
MEAT	Most Economic Advantageous Tender (in Dutch: EMVI)
PCP	Pre-commercial procurement
PPI	Public procurement of innovations
R&D	Research & Development
ROI	Return on investment
RWS	Rijkswaterstaat
SMART	Specific, Measurable, Achievable, Relevant and Time-oriented
SMEs	Small- and Medium Sized firms
TC	Technology commercialization
TCO	Total Cost of Ownership
TRL	Technology Readiness Level
UK	United Kingdom

Table of Content

Chapter 1. Research description

1.1 Context of research

The world is facing tremendous challenges in social, environmental as well as economic aspects. Climate change, scarcity of resources, ageing and an infrastructure that needs to be modernized are some examples of great challenges governments are dealing with. This has resulted in various ambitions and goals among all members of the European Union which are discussed in for example the climate conference in Paris. For the Netherlands the central government has set goals to i.e. achieve 14% sustainable energy in 2020 and a completely sustainable energy supply in 2050, (14% duurzame energie in 2020, n.d.). Furthermore road construction projects will need to be energy neutral during the exploitation phase, meaning sustainable energy from e.g. solar panels need to generate at least the same amount of energy in order for the lights, traffic systems, et cetera to run on. Public procurement tries to cope with these societal problems by supporting the development and application of innovations. Several research concluded that in order to achieve i.e. aforementioned sustainable goals technological innovation is key ((EIT, 2014); (European-Commission, 2014); (Morand, 2006)). Currently the guideline, not a strict target, for buying innovative products is set to 2,5% of the total spending budget of the government, (voortgangsrapportage_innovatiegericht_inkopen, 2013).
The central government is very active on procurement of innovations, especially the Ministry of Economic Affairs, the Ministry of Defence and the Ministry of Infrastructure and Environment (later to be called Ministry of I&E). Research from the Ministry of Economic Affairs has shown in 2012 that 16 from the 82 examined tenders gave some space for innovative solutions during the tendering process. This was also reflected in the desirability rate of innovative products of almost 70% of the contracting authorities in 2012 which is an increase of 24% compared to 2010, (voortgangsrapportage_innovatiegericht_inkopen, 2013). Nevertheless there is still a high need for innovations in order to reach different societal goals within the Netherlands. For example in the road construction industry. Research in 2005 showed that from 58 mapped sectors in the Netherlands, the road construction industry resulted in place 56 as the least innovative sector (EIM, 2005). And still the road construction industry needs great attention to procure innovations. One example which reflects this point of view is the statement of Minister Schultz van Haegen in 2016, the minister of I&E at that moment, saying that the Dutch infrastructure will be energy neutral in 2030, (Rijksoverheid, 2016). It is part of the civil engineering domain which the ministry of I&E is focusing on in order to achieve societal goals. Therefore the market and Rijkswaterstaat (later to be called RWS), which is the executive department of the ministry of I&E for the national roadways in the Netherlands, will need to cope with these development. One way to increase the probability of reaching the stated goals is for innovations to be widely implemented in projects. In this way innovations are scaled up and can contribute to several solutions.

1.2 Problem statement

On the assumption that a ‘”proven” product innovation which is successfully tested, validated and applied in at least one road construction project, and has sufficient added value towards project or societal goals (such as financial, social, environmental and safety) RWS should be willing to have it implemented in all appropriate tenders. A prior assumption is that the contractor is willing to apply the innovation in more projects in order to scale up, since it is necessary for their competitive strength and the viability of their business. When upscaling of a product is successful it could mean that the innovation (or technology as it probably should or could be called) is integrated in the mainstream businesses of both the contractor(s) and RWS. However RWS observes many 'proven' innovations to lack upscaling in practice which are often only applied once. Some of the reasons that were mentioned upfront were: lack of time, money, knowledge, willingness to apply, and too many specifications in the tender that prevent an innovation to be applied in the offer of a contractor. Usually the process of

upscaling is known to require long periods of time, taking at least several decades, (Bosch, 2009). This is especially true for more complex and radical innovations, since these type of innovations demand drastic changes on several aspects. Radical innovations are not easily implemented, which means parties in the chain naturally avoid these solutions. But also some less complex innovations lack upscaling. For RWS the main question is how upscaling of proven product innovations can be stimulated.

1.3 Research goal

Within RWS, it occurs in many projects within the Netherlands that a product innovation is applied successfully for the first time but then due to different reasons isn't applied anymore in other contracts. Especially in the road construction industry where projects are more similar compared to 'wet' projects like a dam, product innovations are expected to be more compatible within different projects and therefore in theory have more chance to scale up. Nevertheless in too many road construction projects proven product innovations are not applied. On the assumption that the product innovation contributes to an improved solution in works of RWS the lack of upscaling is either hindered or prevented by RWS and/or the contractor. The research goal is therefore described as:

To create an understanding on how product innovations, that are successfully applied for the first time in a road construction project, can be applied more often by contractors in order to scale up.

1.4 Central research question & sub-questions

The research question that can be derived from the research objective is described as:

How can RWS influence the upscaling of proven product innovations in road construction projects in the Netherlands?

To answer this research question several sub-questions are described:

1. How does the upscaling process of a product innovation look like?
   1.1 What types of product innovations can be differentiated?
   1.2 What steps can be described defining the innovation process of a product innovation?

2. What influences the process of scaling up product innovations?
   2.1 What factors influences the upscaling process of product innovations?
   2.2 What stimulants are there to scale up product innovations in tenders?
   2.3 What barriers are there to scale up product innovations in tenders?

3. To what extent does the road construction industry influences upscaling practices of product innovations?
   3.1 What is the current situation of the road construction industry?
   3.2 What are the trends and outlook of the road construction industry?
   3.3 What is the current status quo of product innovations in the road construction industry?

4. How are contractors influenced to apply product innovations in tenders of RWS?
   4.1 When do contractors adopt and diffuse a product innovation?
   4.2 What are important stimulants for contractors to scale up product innovations in RWS tenders?
   4.3 What are important barriers for contractors to scale up a product innovation in RWS tenders?

5. How does RWS influence the upscaling of product innovations in their road construction projects?
   5.1 What types of road construction tenders of RWS are there?
   5.2 What is the current status quo of RWS procuring product innovations?
   5.3 How does RWS stimulate the procurement of innovations in tenders?
   5.4 What instruments does RWS use to scale up product innovations in tenders?

1.5 Research methodology

In order the answer the research objective a research question with 5 main sub-questions was formulated. Each sub-question has its own approach to be answered in such a way it meets the stated research requirements for the paper. Different methods will be used which will be explained in order to be able to understand how the data was obtained, what the value is and how it may be interpreted. The next paragraphs will articulate the reasons why certain sources or techniques are used, what the value of different data is and what the scope of the research is in order to keep the research feasible within the time frame.

1.5.1 Model to answer research question and sub-questions

The main goal of this research is to describe how RWS can influence the upscaling process of product innovations in road construction projects. The research will be a qualitative study since RWS has not done a quantitative case study in construction projects combining the factors influencing the upscaling process with product innovations that were applied. Therefore a literature study and mostly field research will be held to create an understanding of the factors that are influential. These can form hypothesis or the basis of a research model that can be used and tested in further research.
To answer the main research question 5 main sub-questions are described. In figure 1 the model to describe the different research techniques for each sub-questions is shown. In paragraphs 1.5.2 and 1.5.3 the reasoning for different types of desk research and field research are described in more detail.

Desk research				**Field research**		
Scientific research	Literature	Reports	Internet	Orientating interviews	In depth interviews	
						1. How does the upscaling process of a product innovation looks like?
x	x		x	x		1.1 What types of product innovations can be differentiated?
x	x		x	x		1.2 What steps can be described defining the innovation process of a product innovation?
						2. What influences the process of scaling up product innovations?
x	x	x	x			2.1 What factors influences the upscaling process of product innovations?
x	x	x	x			2.2 What stimulants are there to scale up a product innovations in tenders?
x	x	x	x			2.3 What barriers are there to scale up a product innovations in tenders?
						3. To what extent does the road construction industry influences upscaling practices of product innovations?
x	x	x	x	x		3.1 What is the current situation of the road construction industry?
x	x	x	x	x		3.2 What are the trends and outlook of the road construction industry?
x	x	x	x	x		3.3 What is the current status quo of product innovations in the road construction industry?
						4. How are contractors influenced to apply product innovations in tenders of RWS?
				x	x	4.1 When do contractors adopt and diffuse a product innovation?
				x	x	4.2 What are important stimulants for contractors to scale up product innovations in tenders of RWS?
				x	x	4.3 What are important barriers for contractors to scale up product innovations in tenders of RWS?
						5. How does RWS influence the upscaling of product innovations in their road construction projects?
		x	x	x	x	5.1 What types of road construction tenders of RWS are there?
		x	x	x	x	5.2 What is the current status quo of RWS procuring product innovations?
		x	x	x	x	5.3 How does RWS stimulate the procurement of innovations in tenders?
		x	x	x	x	5.4 What instruments does RWS use to scale up product innovations in tenders?

Figure 1. Types of desk research and field research used for the sub-questions.

1.5.2 Desk research

Desk research describes the gathering and analysis of secondary data. The data is already available and can be used to describe or explain different theories and/or understandings for topics such as the upscaling of product innovations or the incentives and barriers to implement innovations. The main data that will be used is derived from existing research, especially scientific research which is related to the topic of the research and the branch it is in. Nevertheless topics such as incentives and barriers to apply innovations in for example the medical sector can also be useful to analyse in order to create an understanding since they can cope with similar issues which can be checked afterwards during field research. Furthermore literature, reports and the internet are sources where more information can be found related to a type of study, business process, the company, the sector and so on. Especially the sub-questions 1, 2 and 3 will be based upon desk research since RWS has information about innovations in construction projects but also needs research for the upscaling phase of product innovations which then will be followed up with field research used for research questions 4 and 5.

1.5.3 Field research

Field research will be used to gather qualitative data. It is necessary to gather primary, new data which can be analysed and interpreted in order to be able to answer the research question. To do a thorough field research secondary data via desk research is needed to create a good understanding of the scientific research that has already been done in different fields to see where the focus can or should lie and what conclusions already have been written on parts of the research questions.
Together with the data gathered via desk research orienting interviews will be helpful by giving opinions on important insight viewpoints and where a deeper knowledge is demanded. After the principles on the research topic have been described open questions can be formulated in a structured way which will be used for the interviews with respondents. The orienting interviews together with the personal in-depth interviews will finally support the findings on the topic focused on the construction industry, the contractors and RWS.
First the answers compiled from the open questions during the interviews will have to be rephrased in order for them to be comparable and usable. Therefore coding will be used where answers are described and segmented in subjects such as for example “legislation” as a barrier for product innovations to be scaled up.
The respondents will be experts of contractors in the field of developing and implementing innovations in road construction projects.
To obtain correct and in-depth information the interviews will be recorded. In this way losing information or in-depth answers are less likely to be possible during the conversation which could be the case when taking notes due to a lack of active listening and poor questioning.

1.5.4 Evaluation results

The empirical research that is derived from the field research is important to be executed with prior knowledge as already mentioned. Qualitative interviewing is not a real search for detailed information but rather a guided conversation in order to create an understanding. In this research this understanding though will be combined with existing literature which should make a complete overview of the most important barriers and stimulants related to scaling up a product innovation in the road construction industry.
Results of the orienting interviews of RWS and the interviews with the contractors should be interpreted where large differences should be analysed into more detail to see when and why this is the case.
The results of the interviews will be gathered and checked for differences created by the size of the company. Therefore small-, medium-, and large sized companies will be differentiated knowing these are respectively companies with 1 – 49, 50 – 249 and 250 or more

employees. If a large deviation in the results is found further research will have to analyse the outcomes in more detail looking at the relationship of more variables of the company and how strong they are. For example the amount of financial resources and the learning capability of a contractor could very well influence their view on barriers and stimulants in a great way.

1.5.5 Validity, reliability and generalizability

Most important criteria for measurement quality are the validity, reliability and generalizability of the research' methods that are used and their outcomes.

Validity
Looking at the validity of a research it describes to what extend the outcome of the measurement accurately reflects the concept it is intended to measure (Babbie, p.153).
You have to prove in some way that the research instrument measured what it was supposed to measure. If this is not the case there are systematic faults, also called a bias.
In this research the most important instrument will be the in-depth interviews.
When looking at the internal validity the answers that were given in the interviews could be socially desirable, in such a way that the outcomes could describe conclusions which will benefit the position of the person or their own organization.
By analysing different organizations and checking for large differences in small-, medium-, and large sized companies these biases could be noticed. It is still a potential problem due to the small amount of companies that are active in large RWS projects. Besides comparing these results with each other from the contractor's perspectives the results will be shown to experts of RWS to see if there are any inexplicable answers to exclude these internal validity issues.
Another point of interest are the respondents that are chosen. They are chosen according to the so called purposive (judgemental) sampling, meaning a type of nonprobability sampling in which the units to be observed are selected on the basis of researcher's judgment about which ones will be the most useful or representative (Babbie, p.193).
Together with the experts of RWS the respondents are chosen very carefully. Those experts also have the mediating role to advise and create opportunities for innovations in the market to be implemented in road construction projects. They are expected to have a direct connection to most of the key persons involved with implementing innovations and which relevant companies to contact in order to get the right concerning respondents. Nevertheless in this research one respondent of each company is chosen which could lead to a bias when he or she answers mostly from their own experience and feelings without knowing what is happening within the whole organization at a certain moment. Therefore a great focus still lies towards comparing the results and reflecting them with experts and the founded literature as mentioned before to look for extremes in the outcomes.

Reliability
The reliability of a research describes the quality of the measurement method that suggest that the same data would have been collected each time in repeated observations of the same phenomenon (Babbie, p.150).
Especially the interviews which are held with 1 person of each company can result in a personal answer due to the open questions that are asked. Therefore the answers should be interpreted carefully. For each answer it should be taken into account if it could change very quickly. If this is the case the answers of the personal in-depth interviews may vary from each other. But since large road construction projects will take a couple of years from the beginning phase until the exploitation phase and the amount of large projects that starts every year is limited it is less likely that major changes occur. Nevertheless there are also personal opinions and answers related to for example the willingness of i.e. project managers which can vary between projects. The answers given could be valid for one or more recent projects but not for all projects.

In this research all factors that can influence the upscaling process of product innovations will be described which can be tested in a further research if it is still valid, how it can be handled within each project and how it is related to the working processes of RWS.

Generalizability
The generalizability of the research outcomes refers to what extend research results and conclusions can be used to other people, organizations, countries, and situations, (Aken, van, Berends, and van der Bij, 2007).
The generalizability is limited since the focus will lie on companies that are able to subscribe to large construction projects of RWS. The group of companies that are able to do so is limited but therefore a good representation for the contractors and large road construction projects in the Netherlands. Nevertheless the outcome for road construction projects conducted by provinces and municipalities can be different because of the differences within the tenders. Nevertheless for tenders there are also international legislations and regulations which describe different procuring methods. Therefore the outcomes and conclusions for road construction projects of provinces and municipalities can't be copied one on one and have to be analysed separately where this research could help giving the basic principles of the upscaling process and potential factors that could influence the road construction projects.
Further research should also be carried out in order for the results of this research to be applicable in other countries. Nevertheless it should be a good starting point for other countries to use since the innovation process and tenders are quite similar especially for countries within the European Union due to broad European legislation to which tenders above a certain threshold should abide to.

1.5.6 Scope

The first focus of this research lies towards product innovations instead of process innovations which are also often mentioned and used by contractors in order to reduce e.g. time and money. This has also to do with the fact that the road construction projects are assumed to be very important when upscaling is achieved since these projects have a large physical impact on the environment and therefore can be a large contributor towards the sustainable challenges the government is dealing with. Furthermore the focus will lie on "proven" product innovations which are innovations that are already applied successfully for the first time in a road construction project.
For scaling up product innovations the main focus will lie towards road construction projects (new or replacement) within the Netherlands.
Furthermore it will focus on large road construction projects above 65 million euro since these are executed by the department of RWS called Grote Projecten en Onderhoud (GPO). Also RWS experiences a lack of scaling up product innovations in these projects where they see a high potential and importance for product innovations to be scaled up due to the size of the projects.
In this research only the main contractors of large tenders will be analysed. Excluding the relationship between contractors and small- and medium sized companies who deliver an innovation or are asked to create an innovation. Also the sub-contractors and engineering companies are not taken into account where the research will mainly focus on RWS. The contractor who wins the tender is indirectly depending on the demand and directly, according to their own choices, responsible for the implementation of innovations and can therefore stimulate upscaling.

Chapter 2. Scaling up product innovations - Theoretical framework

2.1 Introduction

The procurement of innovations is a widespread topic that is being investigated from the health care sector, the agricultural sector all the way to the road construction industry. All industries are dealing with new or combined technologies, so called innovations, that will potentially help their business being viable and competitive. These innovations will fulfil the needs of clients and/or users and can potentially solve great challenges for which people are prepared to spend money on. In order to answer the main research question “how to influence the upscaling of proven product innovations in road construction projects of RWS” the first thing to describe is the information available from theory without looking at the construction industry, the contractors or RWS. In the next paragraphs public procurement and innovations in general are discussed, the definition-, importance-, and types of product innovations, and the process of scaling up product innovations. It will create a better understanding about the research topics upscaling and product innovations which are necessary for the rest of the research where in chapter 3 factors influencing the upscaling process of product innovations will be elaborated.

2.2 Public procurement and innovations

Public procurement in general can be seen as the spending of public money. The official definition is described as the “spending of public money to deliver goods, services and works”, (Semple, n.d.). It covers everything from cleaning contracts to buying medical equipment. The total value in the European Union (EU) is estimated at 2 trillion euro per year, which captures around 19% of Europe’s Gross Domestic Product (GDP), (European Commission, 2011). When looking at public procurement in the Netherlands one of the former Dutch ministers of Economic Affairs, Van der Hoeven, started in 2009 with the current approach for procurement of innovations (in Dutch: “innovatiegericht inkopen”). The focus was shifted from the first buyer of an innovation (the government as a so called launching customer) towards the whole procurement process, from strategy creation to upscaling and commercialization.
One of the front runners in the procurement of innovations is the United Kingdom (UK). Edler, Georghiou, Uyarra, and Yeow (2011) concluded that public procurement does indeed spur innovation, 94% of 800 respondents who supply to local and central level of government in England agreed to this statement. Furthermore Edler et al. (2011) concluded that even 25% of the innovating organisations claim that all of their innovations have been the result of public procurement and more than three quarter even reported that innovation has helped them to win other public sector contracts.
The playing field of public procurement in the Netherlands is very broad and decentralized. In general it is conducted by the central government, 390 municipalities, 23 water authorities, and 12 provinces (Bestuurlijke indeling Nederland, n.d.). For the central government the ministries are procuring in their own profession. For the ministry of I&E the procurement of the civil engineering industry (in Dutch: grond-, weg-, en waterbouw (GWW)) is executed by RWS under some predetermined conditions which are described in an infrastructure decree (in Dutch: tracébesluit).
When looking at public procurement of innovations (PPI) the importance of innovation has been recognised in Europe. One important way to measure innovation is the spending of research & development (R&D) by companies against the total GDP of a country or even Europe. Europe in that sense spends less on R&D than the US, Japan and many other countries, (Semple, n.d.). Europe therefore has set a target in 2020 to increase the amount of money invested in R&D to 3% of the GDP of Europe, (Semple, n.d.). As stated earlier societal problems such as climate change and energy sustainability are also emerging as focus areas. Europe’s targets for 2020 are e.g. (Semple, n.d.):

- 20% reduction of greenhouse gas emissions (starting level in 1990);

- 20% of the energy should come from renewables;
- 20% increase in energy efficiency.

These targets can be achieved via different ways such as procuring products which have a higher efficiency (product improvement by e.g. reducing the amount of raw materials used), to increase the product's performance, to recycle products, and so on. But in order to achieve aforementioned targets with a higher pace innovations can potentially create a significant higher value in order to achieve these goals especially when scaled up. When product innovations are scaled up it could eventually lead towards lower prices due to competition between suppliers. The money which will become available could be invested in new innovations or even more of the same innovations. Therefore it is essential that there is a good understanding on what factors influences the upscaling of product innovations.

2.3 Role of the government as a procurer

When looking at the innovation process and the upscaling of product innovations (technologies), which will be discussed in the following paragraphs, the government can have different roles as a procurer. Successful technology commercialization is very important for the companies' business model and to stay competitive. The government can help or hinder this success according to Caerteling, Halman, and Dorée (2008). They described 4 different roles the government has:

1. **Regulator**

The government influences standard settings, where they can introduce and amend laws and regulations in order to increase a quality or safety level of public properties, Caerteling et al. (2008). These could be related to for example the emission of carbon dioxide, use of sustainable energy or the obligation to recycle certain products such as metals or concrete. For new product developments and especially product innovations the regulations can inhibit the development and application of such products. But it can also stimulate particular product innovations to be developed, produced and procured. Important for the government, municipalities, provinces and water authorities is to make a clear distinction where to make space for product innovations, where to standardize solutions and where (in)directly ask for product innovations via laws and regulations.

2. **Sponsor**

The government and related institutions also support product innovation in different stages of their development process. It focuses mainly on specific research & developments projects where they also provide space for innovations to be tested and applied in so called living labs or test centres. They also support the development of innovations in a general way where especially small- and medium sized enterprises can acquire financial stimulus when developing product innovations. These types of companies often have less capital to invest compared to the large companies but can be very innovative due to for example a smaller and more flexible organisation.

3. **First user**

The government can significantly enhance the success of technology commercialization when they apply an innovation in a real project after tests and validations proved the product to be successful. They are then acting as a so called launching customer which is very important for companies to implement their innovation in a real project for the first time since many clients will want a product (innovation) which has several references in similar projects.

4. **Buyer**

The government as a buyer accounts for a substantial amount of money as a public procurer. During the innovation process the main focus lies towards testing and applying a product innovation for the first time in a project. The government is then acting respectively as a pre-

commercial procurer and a so called launching customer fulfilling the role of the buyer and first user. They could even have sponsored the product innovation in the development stages.

Caerteling et al. (2008) described that the government's behaviour as a regulator and sponsor conflicts with its preferences as a buyer and user, see figure 2. After a product innovations was developed there is often only one supplier of a product innovation which makes it difficult to change regulations. On the other hand the regulations are often needed to guarantee the quality and safety of the product but will prevent product innovations to be applied again in a project.

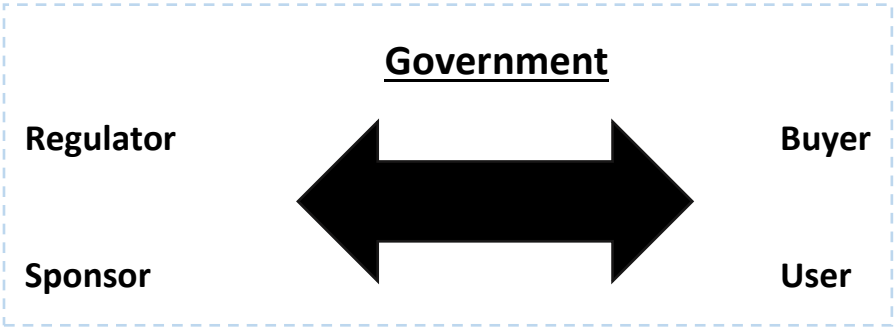


Figure 2. Government as a regulator and sponsor versus buyer and user.

Therefore the support of and demand for new product innovations is often inconsistent and uncoordinated, leaving firms with uncertainties assessing the market potential and the return on investment of their product innovation.
Where the government needs to create a level playing field following the procurement legislations it impedes their willingness to buy the product innovation directly from a supplier. A clear vision from the government telling them which innovations may be applied in the future and in which projects often isn't described or even possible. Focus should lie towards knowledge creation and dissemination in order for several similar product innovations to be developed creating the opportunity to buy product innovations and formulate the market potential in future projects.

2.4 Definition of a product innovation

The definition of innovation itself is being described by various authors so the answer which you will get often depends upon the person, group or company you will ask. One might find it a product innovation if it has a significant improvement in relationship to the current standard he or she uses. This increased improvement is also relative whereas one person may find an increase of 20% functionality that makes it an innovation whereas another person may find a new product an innovation if it increases the functionality by 20% and it is achieved by using a technology with which he or she isn't familiar with. The definition of an innovation is therefore very different and related to the perception of people. Within RWS, who will be discussed in chapter 6, the Corporate Innovation Strategy (CIS) has defined an innovation as, *(*Ridder, de, Boer, de, Vries, de, and Jongejan, 2011a):

"the development, implementation and the use of new products, services or processes which add value to the users of it"

Here you see they focus on different types of the innovation cycle, namely the development, implementation and the use of it. Still a very subjective description is given where "new" could be interpreted differently by persons due to e.g. the current knowledge and experience of one person. Also the "value" for the user can differ and change between persons over time. One well cited author that used the perception of a person into his definition was

Rogers (2003, p.12) who defined innovation as:

"innovation is an idea, a practice or objective perceived as new by an individual, a group, or organization".

This research only focuses on product innovations combined with the definition that incorporated the perception of an individual, group or organization. Furthermore value of a product innovation is the most important aspect. Combining the definition of the CIS and Rogers the definition for innovation that will be used in this research can be rephrased into:

"Innovation is the development, implementation and the use of products which are perceived as new by an individual, group, or organization which add value to the users of it"

A definition is supposed to create a common understanding on what a product innovation is and what is demanded. Notice that the definition is still vague, but that companies will have to describe their demand and so the value of the product innovation they require. The perception could then be a learning curve to inform and educate the whole supply chain in order for all suppliers and clients to be informed on the same level. Still product development and innovation are terms which are closely related and are used interchangeably due to different perceptions of people. Therefore it is best to keep this definition in mind and to look at the goals of each project and the overarching goals the innovation deals with. The value of the product innovation can then be described on the short- and long-term to make the definition specific. It should also be noted that the output should be measurable. An increase of 10% functionality or safety is often not directly clear whereas to reduce the carbon footprint of a certain product could be measured and compared between competitors. Therefore several definitions can be described more explicitly in order to be understandable and usable.

2.5 Importance of product innovation

From a European Union point of view the former Vice-President of the European Commission Antonio Tajani who was commissioner for Industry and Entrepreneurship stated that "Public procurement of sustainable and innovative goods and services is one of the essential tools for stimulating new technological or service solutions while helping to create jobs and boost the competitiveness of European industry and SMEs", (Semple, n.d.). Several sources emphasize the importance of this research which focuses on technological innovation which is key in order to achieve for example sustainable goals mentioned in Horizon 2020, (EIT, 2014); (European-Commission, 2014); (Morand, 2006).
Furthermore if you look at the target of the government to buy 2,5% of their total spending budget on innovations a great part of the budget will be spend on product innovations, (voortgangsrapportage_innovatiegericht_inkopen, 2013).
For high-tech companies commercialization of new product technologies is very important. Especially for research intensive companies it's a key factor for their strategy and success, (Gans and Stern, 2003); (Rothaermel and Deeds, 2004). Companies, especially young small companies are balancing their organisation to explore new technologies or innovations and to exploit existing ones.
In order for governments to be able to buy innovations and for contractors to offer them in projects, adjustments have to be made. First of all some difference between product innovations will be explained in the next paragraph to understand the types of innovation companies are dealing with and what characteristics can be described.

2.6 Types of product innovation

When describing the types of product innovations some clear differences can be made. One of the most distinguished reasons to divide different types of product innovations is related to the technology. When looking at the technology it can be an existing solution or a new solution. When looking at product innovations it relates to new solutions. In general it can be divided into incremental innovations and radical innovations which will each be discussed.

Incremental innovations
Incremental innovations are based upon existing technologies that are combined in order to create a significant increase of value for the organization that developed it and for the client that buys it. Therefore it builds upon existing knowledge and resources and it can be described as a competence-enhancing product, Tushman and Anderson (1986). It can be integrated in working processes relatively quickly due to these facts, nevertheless changes in working processes need to be made in order to deal with the new product innovation. The time that the innovation is accepted and adopted takes less than for a radical innovation which applies a total new technology. Nevertheless the potential to add value is lower than in most projects compared to radical innovations.

Radical innovations
On the other hand a totally new technology could have been invented and developed which can be described as a radical innovation or a so called disruptive innovation. The term radical already implies that it is a game changer. It is a breakthrough for the industry and its users. But on the other hand it also requires new knowledge and resources, and is therefore a competence destroying product innovation which requires for the whole supply chain to change their working processes in order for the innovation (and organization) to be successful, Tushman and Anderson (1986). Therefore adoption of these product innovations require longer periods of time but after it has been integrated in the mainstream businesses the potential value it can add is often higher than compared to incremental innovations.

In table 1 an overview of the characteristics as mentioned of these 2 types of product innovations are described.

Radical innovations	**Incremental innovations**
New technologies	Existing technologies combined
New knowledge and resources	Existing knowledge and resources
Competence destroying	Competence enhancing
Integration in working processes relatively hard	Integration in working processes relatively easy
Adoption time takes relatively long	Adoption time is relatively quick
Potentially higher added value	Potentially limited added value

Table 1. Overview of the characteristics of radical- and incremental innovations.

Another important distinction have to be made which makes implementation and thus upscaling easy or hard. There is a clear difference in mass products which can be applied very easily when they are not very complex, don't influence other products or systems, or can be applied relatively easy since it replaces another part in a modular system. In many cases contractors and engineers have to deal with so called Complex Products and Systems (later to be called (CoPS). CoPS often exists of different, customized and interrelated components. Therefore the design, development and integration are not easy and influences the adoption rate, diffusion and implementation of a product innovation. Another difficulty arises when organizations (competitors) work together in projects. It leads to difficulties when they all have to cope with each other's innovation(s) in CoPS. It could result for product innovations not to be implemented and therefore lack upscaling. Also components differ in their life cycle varying from a couple of years to 100 years which makes it difficult to adjust and get all companies inline. Collaboration and investment decisions are therefore hard and

can prevent some product innovations to scale up. Therefore not only the type of product innovation is important but also the relationship with other products and systems and the complementary knowledge between all stakeholders needed for a successful integration.

2.7 The innovation process

To achieve the ambitions of e.g. major societal challenges, innovations not only need to be successfully applied for the first time but should also be applied on a larger scale. All innovations no matter what type will follow certain steps from an idea phase towards the final commercialization phase of the product innovation. This process is called the innovation process which can be described differently. An innovation process can be described on sector level, company level or more on a product level. The sector and company level often consider an innovation system. An innovation system can be described as:

A group of private firms, public research institutes, and several of the facilitators of innovation, who in interaction promote the creation of one or a number of technological innovations [within a framework of] institutions… which promote or facilitate the diffusion or application of these technological innovations (Beije, 1998, p. 256).

For this research the focus will lie on the innovation process related to the development, adoption and implementation stages of a product. Nevertheless incentives and barriers that can influence the upscaling process of a product innovation can also be related on several other levels such as the company level where the government could be a facilitator for product innovations. If we look at the terms commercialization and upscaling they are described differently. The commercialization process can be simply divided into three stages, (Jung, 2015):

(1) technology acquisition
(2) prototype testing
(3) product manufacturing

Since there are more critical stages during the technology commercialization process the technology readiness level (TRL) is often used which was described by NASA, (Mankins, 1995). They described 9 levels through which a technology will go in order to be a proven technology and officially able to be commercialized and scaled up, see figure 3.

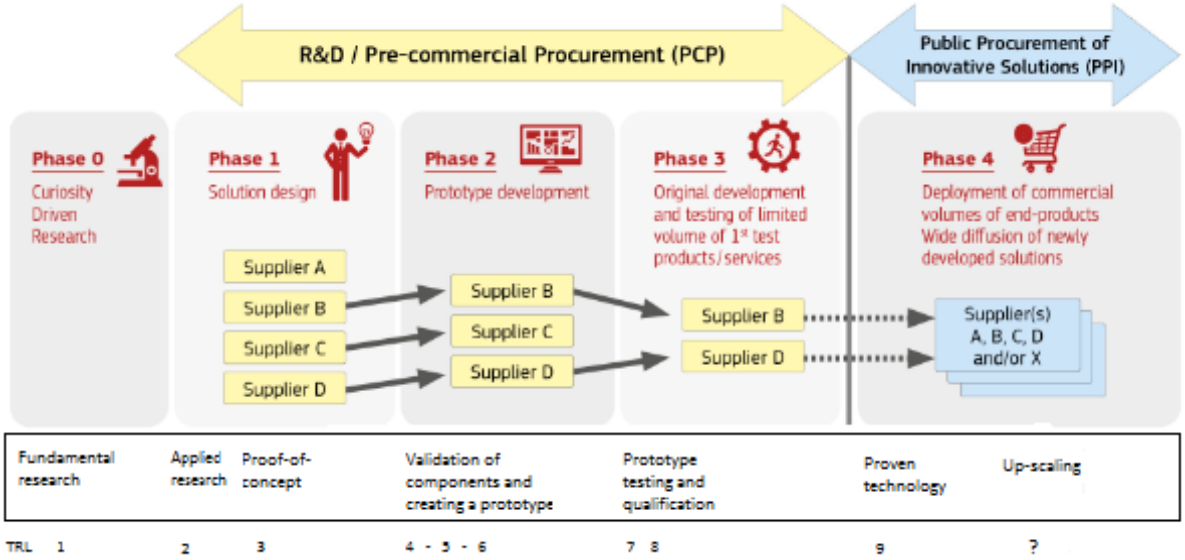


Figure 3. Technology Readiness Levels 1 to 9 versus PCP and PPI, (Digital Single Market, 2016), (Mankins, 1995).

The first three levels include fundamental research, applied research, and getting a proof-of-concept which has market potential. The levels 4 through 6 are focused on validating the components and creating a prototype that can be tested in a relevant environment. The levels 7 and 8 are all about testing the prototype and qualifying it for industry standards. Finally level 9 is the first project where the technology is applied and can potentially be called a 'proven' technology. When looking at the public procurement of innovations, the main focus lies on getting the innovation through levels 7, 8 and 9. In procurement terms the levels 7 and 8 are the prototype testing and qualification level, also known as pre-commercial procurement (PCP) and in level 9 the government is acting as a so called launching customer which relates to the start of the phase which is also known as the public procurement of innovations (PPI), see figure 3.
The stage after TRL-9 can be described as the “upscaling of an innovation” and when looking at the commercialization stage it occurs when the sales volumes of products rise and the price often will drop with it since competition is often closing in or already there. It is exactly step 9 which is the starting point for this research ultimately leading towards step 10 where a product innovation is widely adopted and implemented. In the next paragraphs the focus will lie towards the upscaling phase of a product innovation, its definition and its importance.

2.8 Upscaling product innovations

2.8.1 Characteristics of product innovations to scale up

In the upscaling stage of product innovations new techniques will eventually be turned into mainstream business practises, see figure 3. In this process the innovation evolves from a niche solution towards a broadly accepted solution. Meaning all companies have to learn the advantages of the innovation and have to develop know-how on its application and use, (Sandick, van, and Oostra, 2010). Thus not only the supplier or contractor but also the client. Employees who are involved often have to change their competences and habits. It also means that all relevant organizations needs to adjust their infrastructure and want the innovation as mainstream application, (Sandick, van, and Oostra, 2010).
Additionally it was found that upscaling occurs in the technology lifecycle period when the (radical) innovation is embedded as the dominant design, (Frenken, 2000). A dominant design (originally formulated by Utterback, 1975) is when it appeals to various users (beyond particular niches), and settles core design concepts in both components and their integration in a complex assembled product (CoPS as described earlier). It leads to competition between comparable products where the innovation will be integrated into a standard manufacturing process. Whereas a radical innovation may introduce a wholly new set of trade-offs between a product’s technical and service attributes, subsequent incremental innovations hold this trade-off constant while varying scale so as to adopt the dominant design to particular market segments, (Frenken, 2000). Commercialization ensures that the technology in question meets not only the performance and reliability requirements, but also the consumers’ demands, (Jolly, 1997); (Nerkar, 2007). For upscaling it is important that it not only meets the demands of the consumers and stakeholders related to one project but should also focus on the demands which are needed to implement a product innovation on a broad scale of projects. Some characteristics of radical- and incremental product innovations are added to table 1 to make a better overview focusing on upscaling, see table 2.

Radical innovations	**Incremental innovations**
New technologies	Existing technologies combined
New knowledge and resources	Existing knowledge and resources
Competence destroying	Competence enhancing
Integration in working processes relatively hard	Integration in working processes relatively easy
Adoption time takes long	Adoption time is relatively quick
Potentially high added value	Potentially limited added value
Upscaling characteristics	**Upscaling characteristics**
Innovation embedded as a dominant design	Innovation embedded as a dominant design
New set of trade-offs between a product's technical and service attributes may occur	Constant set of trade-offs between a product's technical and service attributes
Meets performance- and reliability requirements	Meets performance- and reliability requirements
Meets consumers' demands for a broad range of projects	Meets consumers' demands for a broad range of projects

Table 2. Overview of the characteristics of radical- and incremental innovations plus additional upscaling characteristics.

2.8.2 Definition upscaling

A lot of mistakes are made towards the terms and definitions of commercialization and upscaling of a product innovation. In short the definitions and a short explanation of the differences are described. When discussing commercialization of a product innovation the term "**technology commercialization**" (TC) can also be used since commercialization is related to the acceptance of a wide market when a product has already evolved in the diffusion process, elaborated in the next chapter. The definition of technology commercialization can be defined as:

"the process of moving a technology or innovative concept from laboratory to market acceptance and use", (Chen, Chang, and Hung, 2011).

Upscaling can be defined as:

"The process in which broad implementation of an innovation is achieved", (Sandick, van, and Oostra, 2010).

Sometimes a distinction is also made between vertical and horizontal upscaling. Vertical upscaling is related to applying a product innovation in large volumes without drastic changes in the product innovation itself so no broad adoption occurs.
Horizontal upscaling is also related to volumes but is more focused on adopting and applying the product innovation in order to be implemented in a broad range of projects and/or industries. Therefore the compatibility and the adjustability of an innovation are important. For this research the focus will lie towards horizontal upscaling were the goal is to know how product innovations can be applied in a broad range of road construction projects of RWS.

The main difference between commercialization and upscaling is that upscaling occurs when a product or innovation successfully reached TRL-9 and is then broadly implemented. All parties in the supply chain are then able to cope with the innovation. Especially the client and the supplier, who will have the innovation integrated in their mainstream business and embedded the product as a dominant design.
Commercialization is often focused on the business to consumer market, focusing on the market acceptance and use, and therefore meeting the consumers demands. It is part of the characteristics needed for a product to scale up. Without a product innovation to comply to the consumers' demands on a broad range of projects it will not be embedded as the

dominant design and it will not be scaled up. Therefore commercialization and upscaling are interrelated but in this research we will only use the term upscaling or TRL-10.

2.8.3 Importance of upscaling product innovations

When discussing the upscaling of product innovations the crucial role lies towards the adoption of an innovation at both the supplier or contractor as with the client. The upscaling of product innovations thus implicates that all parties have adopted the innovation whereas the innovation can be diffused and broadly implemented. Upscaling is not only important for the buyer to solve (societal) problems, or increase value for the users, but also for the supplier and/or contractor to earn money with it and increase their competitive advantage. In order to keep their company viable and financially healthy a company wants to earn its investment back within a couple of years. Zahra and Nielsen (2002) also stated that successful technology commercialization and entrepreneurship is important for a firm to stay competitive and to survive in an continually changing environment.
When looking at public procurement of innovations it is often guided by legislations and regulations which makes the calculation of market opportunities for product innovations very difficult. They often deflect the current standards and it is often unclear if and when these regulations will be changed. Therefore it could prevent a product innovation to be embedded as a dominant design.
In general the relationship between the client (in this research public procurers), the supplier (in this research the contractors), the tender, the product innovation and upscaling are visualized in figure 4.

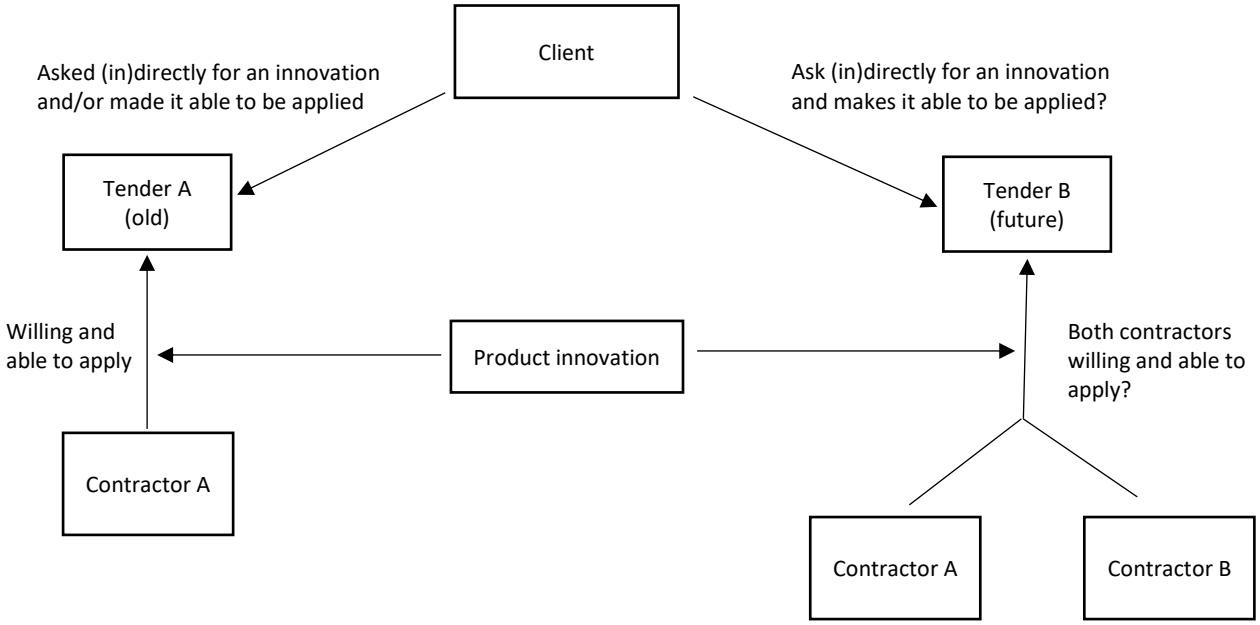


Figure 4. Overview of a product innovation and the client and contractors in multiple tenders.

The client needs to make space for an innovation to be applied in all possible tenders. Furthermore they can (in)directly ask for a product innovation to be applied. On the other hand the contractors should be willing and able to apply the product innovation in order for the product innovation to be scaled up.

2.9 Conclusion

When looking at product innovations to be procured different companies play a role in the supply chain. Focusing on public procurement the government has 4 main roles. They can act as a sponsor, regulator, first user and buyer of a product innovation. Caerteling et al. (2008) concluded that the support of and demand for new product innovations often is inconsistent and uncoordinated. It leaves firms with uncertainties on for example the market potential, return on investment and profit of a proven product innovation.
When looking at the definition of product innovations it could differ for an individual, group or organization as their perceptions can vary of what is new and what the added value is towards the user(s). In general product innovations are differentiated into incremental innovations and radical innovations which are respectively competence-enhancing and competence-destroying products. If they are closely related to other parts of a total solution it is important to understand how different products and systems are connected.
When looking at the innovation process the focus will lie towards TRL-10, after which an innovation was successfully applied once and is ready to be scaled up.
Looking at the characteristics of product innovations in relation to upscaling some can be described as important. First of all the product innovation needs to be embedded as the dominant design at the client(s) and the contractor(s) in order to scale up. Furthermore new or a constant set of trade-offs between a product's technical and service attributes may occur, the product innovation has to meet performance- and reliability requirements and finally it has to meet consumers' demand for a broad range of projects.
Since there are a lot of individuals, groups and organizations involved it is a very difficult and complex situation whereas these characteristics can vary between products, projects and organizations. In the next chapter factors will be described which could influence this upscaling process.

Chapter 3. Influencing the upscaling process - Theoretical framework

3.1 Introduction research question

When discussing the upscaling of a product innovation it is important to know within each organization who the adopters of different types of innovation are. These adopters can be described as an ambiguous set of decision-makers where two different sides have to be dealt with. The client and supplier should both be willing to adopt and able to cope with the product innovation in order for it to be applied in a tender. Since a lot of critical key decision-makers have their own skills, experience and knowledge on current innovations, a technology could be perceived differently as an innovation. Therefore among those key decision-makers different innovation-decision processes occur and together determine the adoption rate and the upscaling process of a product innovation. The adoption and diffusion of an innovation is very critical among those key decision-makers and could therefore slow down or even stop the upscaling process of a product innovation. Assuming that a product innovation is applied successfully in a project and has some degree of added value for the user it is important to understand why it lacks upscaling. Several factors will be considered which are important. In the first place the innovation-decision process of the supplier but also the client to continually adopt and apply a product innovation in a tender will be discussed. Looking at the broad implementation of product innovations each tender has its own conditions and could therefore influence if a product innovation could be applied in more tenders. The client have to make space in order for the product innovation to be applied. Also different key persons can play a significant role between tenders of both the client and the contractor. The innovation itself plays an important role where both the client and the contractor need to be able to cope with the innovation in different ways. Finally the demand is described in a tender which should not only make space for it but in order for product innovations to be scaled up the tender should ask (in)directly for it. It can influence the willingness and ability of a contractor to apply and therefore to scale up a product innovation. After describing the factors that can influence the upscaling process of product innovations, stimulants and barriers for upscaling are described of which antecedents are then extracted.

3.2 Factors influencing the upscaling process

When looking at the application of a product innovation and its broad implementation in projects there are several factors which can influence this upscaling process. Since tenders are very specific, each project should focus on how and when “proven” product innovations are applied and since an innovation is also related to the perception of key decision-makers this process is critical and not only focused on one project. Diffusion among decision-makers of a product innovation is therefore essential for implementation on a broad scale since each individual and/or organization has to make a decision at a certain moment to adopt and implement the innovation. Research on the adoption and diffusion process of innovations are mostly based and cited upon the diffusion of innovation theory of Rogers. In his point of view adoption of a technology or innovation is a decision of “full use of an innovation as the best course of action available” and rejection is a decision “not to adopt an innovation”, (Rogers, 2003, p. 177). On the other hand in order to scale up diffusion is necessary not only towards one contractor and the client but all key decision-makers of the client and contractors. According to Rogers (2003, p. 6) he stated that social change occurs when a new idea is invented, diffused, and adopted or rejected which leads to certain consequences.
In general the importance of the diffusion of a product innovation in a social system will be discussed, how the innovation decision-making process can influence broad implementation and how elements of the tender itself can be influential in the upscaling process.

Diffusion of product innovations:
Rogers describes 4 main elements in his description of the diffusion of an innovation (Rogers, 2003, p.5):

Diffusion is described as the process by which (1) an innovation (2) is communicated through certain channels (3) over time (4) among the members of a social system.

These 4 elements, which together influences the diffusion and thus upscaling of a product innovation, will determine if key persons have heard of the product innovation and are familiar with i.e. the competences and consequences they have to deal with. It therefore also provides an understanding towards those persons and will strengthen the perception of these decision-makers towards the product innovation in a positive, neutral or negative way.

1. Innovation

The first element is the innovation itself. When looking at product innovations it can't be assumed that they are equivalent units of analysis since the attributes of an innovation could be perceived differently by each individual, organisation or even a sector. It helps to explain the different rates of adoption by decision-makers and why a product innovation is not adopted anymore and therefore upscaling is not achieved. Important attributes that need to be taken into consideration are:

a) Relative advantage
b) Compatibility
c) Complexity
d) Trialability
e) Observability

These attributes or characteristics can be key in making a decision whether to adopt or reject an innovation for a project and can therefore hinder or stimulate the upscaling of an innovation. It is also the first stage describing the prior knowledge in the decision-making process which will be discussed later on. Each attribute will be shortly described:

a) Relative advantage:

Is the degree to which an innovation is perceived as better than the idea it supersedes, Rogers (2003, p. 15). It can be measured in different terms:
- Economic (material costs, maintenance costs, return of investment, life cycle costs, etc.);
- Social (prestige, status, social importance for the users, -municipalities, -provinces, etc.);
- Environment (carbon dioxide, recycle potential, amount of material used, etc.);
- Other factors related to the product innovation and the needs of the adopter.

The objective analysis of the adopter towards the relative advantages is often less relevant. The perception of an individual towards the product innovation and its advantageous and consequences are more important. Relative advantages are also hard to measure which makes it difficult to compare to the product it supersedes. In general the better the advantageous perception of an individual is the higher the rate of adoption will be.

b) Compatibility:

Is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters, (Rogers, 2003, p. 15).
The assumption is that when an innovation is incompatible with the current norms and values of a social system, the innovation is less likely to be adopted. It often is a very slow progress taking a lot of time to change. Projects often describe different goals and variables, therefore product innovations are required to be adjusted if necessary to project specific requirements in order to be applied again. It is therefore related to the horizontal upscaling as mentioned before. An innovation does not necessarily has a standard template or a passive technology. Re-invention is sometimes inevitable for a product innovation to be applied again in different projects and therefore to scale up.

c) Complexity:
Complexity is the degree to which an innovation is perceived as difficult to understand and use, (Rogers, 2003, p. 16). Some innovations, often incremental innovations which combine existing technologies, are easily understood by most members of a social system. Whereas more complex technical innovations are adopted more slowly and require more understanding and teaching in order to be adopted by a social system.
When discussing complexity and why a company doesn't want or isn't able to apply an innovation is mostly affected by its in-house competences. Therefore the complexity of an innovation can roughly be described as a competence-destroying or competence-enhancing product, (Tushman and Anderson, 1986). Competence-destroying product innovations require new organizational skills in order to adopt, apply and/or maintain the innovation. On the other side competence-enhancing product innovations are those that build on existing organizational know-how. The simpler and easier a product innovation is to understand the faster it is adopted whereas those which need a great amount of training and knowledge to understand and use will take longer to be adopted. It can even be rejected if there is a lack of resources such as time and money to acquire knowledge and competences in order to apply a product innovation. Finally if the product is part of a CoPS it is more likely that several organizations and suppliers have to deal with the innovation and will make it more complex to deal with. It could prevent upscaling to occur if not communicated and managed properly throughout all relevant companies in the supply chain.

d) Trialability:
Refers to the degree to which an innovation may be tested on a limited basis, (Rogers, 2003, p.16). New innovations that can be tried on forehand will generally be adopted more quickly. Whereas high uncertainties for the adopters occur when innovations cannot be experimented on a limited scale. Occasionally an innovation needs to be adjusted to the circumstances of a project which can vary in accordance to the project in which the innovation was originally applied. To decrease risks it can be important to test the innovation on forehand on a small scale by the supplier, contractor, research institute or other companies involved.
Nevertheless this is only the case when an innovation needs to comply to regulations which can differ due to the circumstances and requirements. After an innovation has proven itself it should be of less importance for the rate of adoption since the innovation is applied and analysed. But it is then important for the persons that will adopt the innovation to have insight and in-depth information before it is of less importance, therefore diffusion is very important. If there is a lack of inter-project learning for example trialability should be a point in the agenda to get all key-decision makers in a social system informed in an early stage.

e) Observability:
Is the degree to which the results of an innovation are visible for the individuals of the social system related to a project, (Rogers, 2003, p.16). When the results are more evident and accessible it will be adopted more easily and it will stimulate the peer discussion of a new innovation. It then becomes easier to compare and to adopt since it is often an innovation which is only on the market for a short time and needs to prove itself on many levels for each project. Most importantly the individual or social system needs to get evaluation information on the innovation in order to create a positive understanding.

When looking at these five attributes of an innovation former researchers found that these were the most important characteristics in explaining the rate of adoption of an innovation, (Rogers, 2003, p. 17). For the rate of adoption the relative advantage and compatibility of a product innovation are the most important attributes. When an innovation is adopted faster it is more likely that an innovation will be scaled up. It is also important to know if there is a moment where a lot of decision-makers adopt the innovation and form a critical mass leading to upscaling. Which relative advantages are the most important is presumed to be related to different projects and circumstances and differ between members among a social system.

Another important aspect which Rogers described is that he claimed that there is a lack of diffusion research on technology clusters. He explained “a technology cluster consists of one or more distinguishable elements of technology that are perceived as being closely interrelated”, (Rogers, 2003, p. 14). We already described it as CoPS. Often an innovation is analysed as a single independent unit and its adoption rate whereas it is often interrelated with other products and/or product innovations. Therefore combining a product innovation with other known products can increase the rate of adoption and can increase the advantages and reduce uncertainties. The relationships and impact of the product innovation with other products should be described and analysed. It can also be said that for this reason compatibility is therefore very important. Nevertheless for a single product innovation to be adopted and spread in the market, communication should take place. It is the second element of the diffusion process.

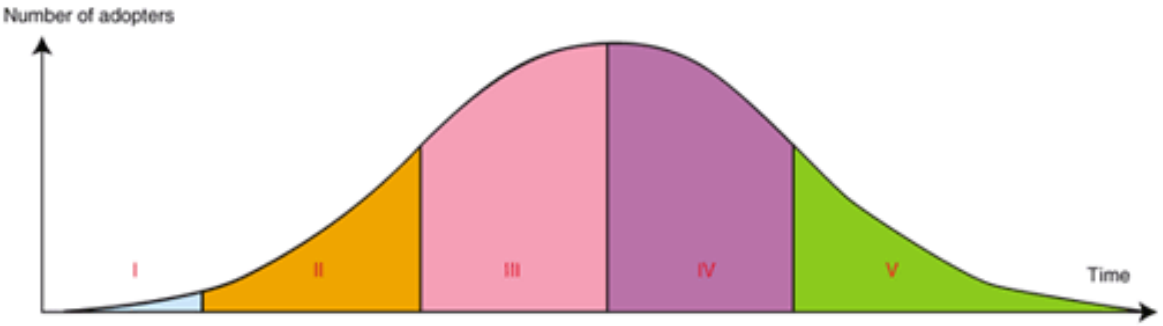
2 Communication channels

Communication can be defined as the process by which participants create and share information with each other in order to reach a mutual understanding, (Rogers, 2003, p. 18). For an innovation it is essential that information is exchanged towards one or more individuals. The supplier or an individual who has experience using or has knowledge of the product innovation needs to inform another individual or several units of adoption that do not yet have the knowledge and experience of the product innovation. It is especially important to know who are the key persons that make a decision whether to adopt or not.
One way to communicate is through mass media such as television, radio, newspapers or professional journals. Nevertheless when trying to persuade an individual (unit of adoption) to adopt an innovation it is more effective via interpersonal channels. It is the face-to-face meetings that will have a subjective persuasiveness of an innovation which is conveyed by users of the innovation. For example a project manager can persuade a colleague a lot easier than an unknown person. Diffusion is in a way a very social process. The personalities of key persons (unit of adoption) are therefore important to take into account but will not be addressed in detail in this research.
Communication can inform individuals to create an attitude before he or she initially decides to adopt and eventually apply an innovation. Communication can give insight information about important issues such as the relative advantages and the consequences or risks a company has to deal with. It is therefore an essential part of the innovation process in order to scale up product innovations.

3 Time

The third element in the diffusion process is time which can be measured as the number of members of the system who adopt the innovation in a given time period, (Rogers, 2003, p. 20). Rogers (2003) conceptualizes 5 steps in which the adopter learns from an innovation until the decision to adopt is actually confirmed. These are the steps which describe the innovation decision-making process which will be discussed later on. Individuals differ in this innovation-decision period whereas some need years to adopt and others are rapidly shifting from getting the knowledge towards actually implementing it. Most focus is currently placed at the individual level whereas the innovation-decisions are often made by multiple persons or even a whole organization as the unit of adoption.
Nevertheless time is important in the communication of information towards the social system since it can bring a momentum when done properly to pace the upscaling of a product innovation or at least give the social system proper information before a project has been formulated in too much detail or an offer for a tender has already been submitted.
When looking at the decision-makers, the units who adopt an innovation can be described in terms of their innovativeness. Innovativeness is the degree to which an individual is relatively earlier in adopting new ideas than the other members of a system, (Rogers, 2003, p. 22). Rogers (2003) describes 5 adopter categories namely:
1. Innovators
2. Early adopters

3. Early majority
4. Late majority
5. Laggards



Category	I. Innovators	II. Early adopters	III. Early majority	IV. Late majority	V. Laggards
Percentage	2.5%	13.5%	34%	34%	16%
Characteristics	· Venturesome · Interested in new ideas	· Convey ideas of innovations to others. · Greatest degree of opinion leadership	· Deliberate · Adopt new innovations just before the average member of a system.	· Skeptical · Adopt new ideas just after the average member of a system.	· Traditional · Suspicious of innovations · Last to adopt an innovation · Not opinion leaders

Figure 5. Adoption rate of innovations by individuals over time and their classifications, (Rogers, 2003).

As you can see in figure 5 each type of adopter has its own characteristics. It's important to understand what type of key decision-makers you are dealing with in order to understand how quickly they will probably adopt an innovation and so how many effort you have to put in and how many information you need to give for a positive attitude. It is therefore important to communicate the advantageous of the innovation and describe what a company and a key decision-maker can expect from the product innovation. It should also be integrated in working processes in order for the adoption rate to be higher.

When looking at the upscaling of a product innovation the rate of adoption is very important. It is defined as the relative speed with which an innovation is adopted by members of a social system, (Rogers, 2003, p. 23). When you sum up the adopters cumulatively over time the distribution curve will often be S-shaped. It will vary in the slope of the "S" depending on the innovation, see figure 6. The rate of adoption is mostly measured for an innovation in terms of the members of a system instead of individuals as the unit of analysis. The system can be an organization or even a sector as the unit of adoption. In the social system of an organization it is still important to keep in mind that the rate of adoption of an innovation is different due to the organization's system. It can directly affect its decision to adopt because of their own norms, strategies, vision, culture or possible influential members of the social system. Time, money, agreements with sub-contractors or a specific innovation strategy could be some of the factors that could determine an individual or organization's decision to adopt an innovation or not.

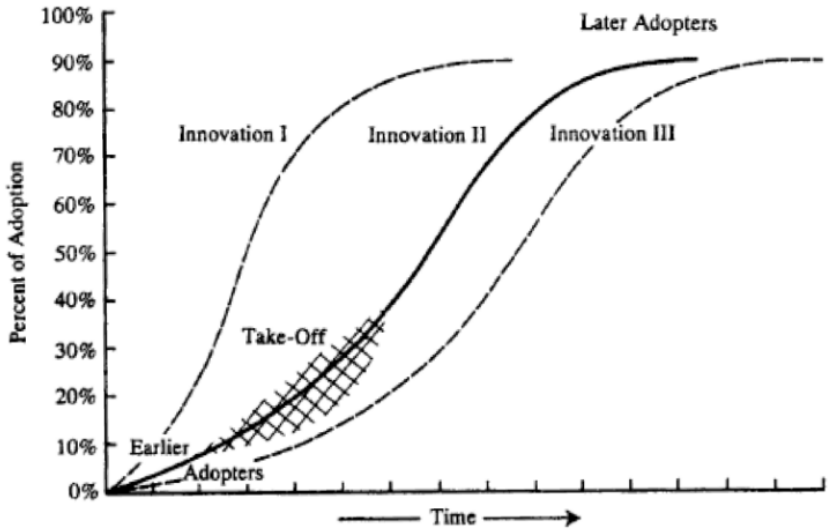


Figure 6. Cumulative percentages of adopters of an innovation over time (Rogers, 2003, p.11).

When looking at figure 6, you can see that there is a difference in the adoption of different types of innovations. The first innovation is far steeper which means that it is adopted much easier and quicker. This could especially be the case for more simple innovations which don't demand a whole new set of competences or are related to more components and products (CoPS). These innovations, often incremental innovations, are supposed to be adopted far quicker than for example radical innovation where the s-curve takes off at a later point in time. The relative advantages and the compatibility are important to increase the adoption rate. Social systems are critical in determining the adoption (rate) and implementation of a product innovation.

4. Social system

A social system can be defined as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal, (Rogers, 2003, p. 23).
The members cooperate to solve a common problem in order to reach their own stated mission and vision. The social structure can influence the diffusion of an innovation. It can have arrangements that will stimulate an innovation or just simply reject it. It could be a formal structure where for example in a governmental organization persons with higher functions will have more responsibilities and can influence and/or give orders to those of lower ranks. Informal structures in the interpersonal networks linking a social system's members can be important to know who are decision-makers related to a product innovation and who to persuade. Both can facilitate or impede the diffusion of innovations according to Rogers (2003). Katz (1961) remarked "it's as unthinkable to study diffusion without some knowledge of the social structures in which potential adopters are located as it is to study blood circulation without adequate knowledge of the veins and arteries".
However only few studies did research on how a social structure or a communication structure affects the diffusion and adoption of innovations in a system, (Rogers, 2003, p. 25). The structures of the social system will not be elaborated in detail in this research due to the complexity and the time factor but will be addressed as an important factor to scale up product innovations.

Innovation-decision process

Whereas innovation is a term which is interpreted differently among members of a social system Rogers often uses “technology” as a synonym. In his eyes “a technology is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome”, (Rogers, 2003, p. 13). Whereas members of a social system are a set of interrelated units to accomplish a common goal it is important to understand why decision are made. The most important process that leads to the implementation of a product innovation is the innovation-decision process which essentially is an information-seeking and information-processing activity in which an individual is motivated to reduce uncertainty about the advantages and disadvantages of the innovation, (Rogers ,2003, p.14). When summarizing the innovation-decision process Rogers described it in five steps, see figure 7, (Rogers, 2003, p.170):

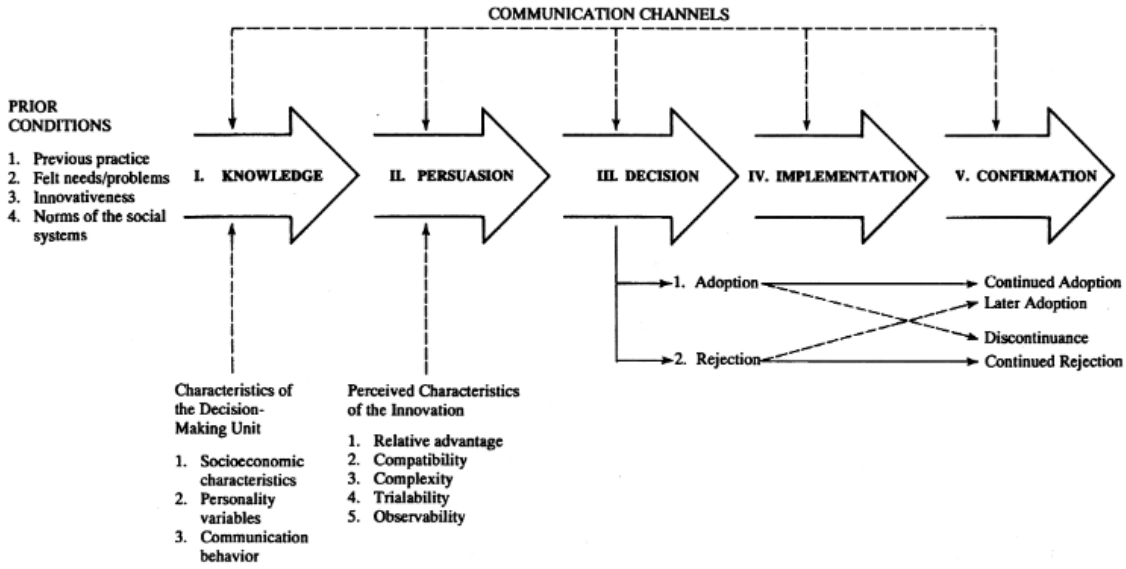


Figure 7. Model of the five stages in the innovation-decision process.

These 5 steps are:

I. Knowledge: an individual or decision-making unit is exposed to a product innovation and receives information on the application and properties.
II. Persuasion: an individual or decision-making unit creates a positive or negative attitude towards the product innovation.
III. Decision: the individual or decision-making unit is involved in activities leading to a choice to adopt or reject the product innovation.
IV. Implementation: the individual or decision-making unit puts the new product innovation into use.
V. Confirmation: the individual or decision-making unit needs to reinforce a former decision made which may be reversed if conflicts that arose about the product innovation can’t be solved.

It also describes prior conditions that influences the knowledge stage which also has to deal with the characteristics of the decision making unit. The innovativeness of the person, his or her norms, beliefs and competences are some examples which will influence what a person knows but also in what way her or she looks for information. These prior conditions should be described in the stimulants and barriers that influence the upscaling process. In the persuasion step the innovation itself is the important factor of influence where the perceived characteristics of the product innovation described as the relative advantage, compatibility, complexity, trialability and observability will play an important role. These are all relevant factors in order for a product innovation to be adopted or rejected where the goal is to create

a willingness for continued adoption and then implementation to achieve upscaling in the confirmation stage. Each step will be elaborated in more detail.

I. Knowledge stage

The innovation-decision process starts for a decision maker when he or she is exposed to a product innovation's existence and gains information on the basic functions on how it works. When discussing the prior knowledge needed to create an understanding about how the product innovation functions, the individual or decision-making unit gets a so called awareness-knowledge. There is a great difference between accidently getting aware of a product innovation or being actively made aware of the information where the decision-making unit is actively seeking or is informed by for example the supplier of a product innovation. In the first situation which could be a coincidence it could very well be that in a later stage of the decision-making process they are an active seeker informed by their communication networks or so called peers. Whether or not they are active is influenced by their current interests, needs and existing attitude. It also relates to the innovativeness of the decision-maker where an innovator is more often an active information seeker and the rate of adoption is higher. Where on the other hand an individual could be part of the so called late majority meaning he or she is very sceptical and adopts an idea after the average member of a social system does.

In general Rogers (2003) describes 3 types of knowledge about an innovation:

a. Awareness knowledge
b. How-to knowledge
c. Principles knowledge

The awareness knowledge is about the basics an innovation exists and it can motivate individuals to inform on knowledge types b and c. It can be directly related to solve an existing need or it can create a need which the decision-maker wasn't aware of. For example a new medicine could solve an existing allergy but did the consumer really needed bluetooth or is it just a convenience product? The how-to knowledge explains how to use the innovation properly whereas the third type, the principles knowledge, explains more know-how on the underlying principles needed to cope with the innovation in practice.

II. Persuasion stage

After the individual or decision-making unit has the knowledge of a product innovation he or she can form an attitude towards it. Whereas every product innovation has some degree of uncertainty the decision-maker seeks for social reinforcements and starts by thinking what if I adopt this innovation, he or she starts with forward planning in this stage. The perceived characteristics of the innovation are therefore very important. In this stage the characteristics such as the relative advantage, complexity, compatibility, trialability and observability will create decisions and discussion within social systems whether or not they want to learn more about the innovation, spend resources on it, hear about the experiences when it was implemented for the first time and so on. It will form the basis for the next stage whether to adopt or not.

III. Decision stage

When a positive attitude have been made towards a product innovation the individual or decision-making unit participates in activities that lead to adoption or rejection of an innovation. One way to reduce uncertainties is when a product innovation can be seen and tested on a small scale, so the trialability and observability can reduce risks and uncertainties which could lead to a positive decision. When an individual and later on also the organization wants to adopt the innovation it also will be looking at the market potential. It is clear that tenders differ due to several reasons such as environmental aspects and regulations which means there is a possibility it can't

simply be applied in all tenders. So if the willingness to apply an innovation doesn't always level to the ability of implementing it the decision to reject is more common. Often there is an implicit assumption that there is a linear sequence in the innovation-decision process knowing knowledge-persuasion-decision. In some cases it could very well be that there is a knowledge-decision-persuasion sequence. For example if regulations or a contractual design explicitly demand a certain type of product innovation. A contractor could very well hear about the innovation, then needs to adopt it and in a later stage is persuaded of its advantageous. Also the pressure of a social system to adopt a product innovation could precede the decision of an individual.

IV. Implementation

Until this stage the innovation-decision process has strictly been a mental exercise. Now the actively information-seeking process start to take place. There is still a certain degree of uncertainty about the consequences that can occur when implementing the product innovation. Questions such as where to buy it, the order amount, price, how to install, maintain and how to integrate it in the working processes are to be answered. It is important for the contractor but also for the client if they have to do the maintenance and are not familiar with the product innovation yet. In an organizational setting several individuals are involved in this process since they all need to work together and have to cope with the product innovation. In this stage the decision-maker could be a person with higher authorities and other employees are asked or demanded to learn about the innovation and integrate it in their working processes. This could often lead to resistance of some individuals to implement it. Another important aspect of the implementation is the possibility of an innovation to be re-invented. It is the degree to which an innovation is changed or modified in order to be applied again, (Rogers, 2003). It is often necessary in order to scale up where especially complex innovations have to be adjusted to certain circumstances in different projects but also to the changing needs of the client(s).

V. Confirmation

The last stage does not necessarily have to occur but due to different reasons is one which can't be denied. When a decision-making unit becomes aware of a need such as the sustainability of a product innovation it can reconsider whether or not to adopt and implement the product innovation again. Wishes and demands throughout the whole social system on an individual, organizational or governmental level can change over time. Therefore it is important to continually inform, question and check whether the implemented products fulfil the existing needs and potential needs in the future such as the horizon 2020. Another product innovation could very well supersede the implemented product innovation at a certain moment in time and will therefore be replaced. After a product innovation has been implementation the outcomes can be different than on forehand expected. It is therefore important to evaluate and adapt quickly in order to retain negative attitudes and effects which can stop an innovation for being implemented again and therefore to scale up.

Tender:

To influence the upscaling of a product innovation the tender can ask directly or indirectly for innovations. Looking at the demand it is important that the specifications give space for innovations to be applied. One option is through functional specifications which can indirectly stimulate the application whereas it is not limiting products to be applied based on their technical specifications. Furthermore fictional price discounts for added value, which can be achieved by using product innovations, can stimulate the upscaling of innovations. Nevertheless regulations and legislations described in a tender are important for the safety and quality of the public space but can also inhibit or stimulate the use of innovations. Also the size and duration of a tender can influence a decision whether to implement a product

innovation. If a tender is large and has a long duration it can affect several aspects such as the return on investment and the total cost of ownership of a product innovation. Since tenders differ in each sector but also between projects it will be discussed in more detail in chapter 4 about the road construction industry and chapter 6 about RWS as the client.

When looking at the factors that influences the upscaling process it can be conducted into the following model which is focused on the innovation-decision process of a social system (individual, organization and sector), see figure 8. Furthermore the model includes the different types of social systems and describes the characteristics of the decision-making unit to be relevant in the knowledge stage but also the prior conditions such as the existing knowledge, needs (problems), norms, values and beliefs of an individual. The characteristics of the decision-making unit such as its (innovation) strategy, vision and resources can also influence the decision not to adopt and embed the innovation as a dominant design which prevents upscaling to occur. The last factors in the model are related to the diffusion process focusing on the innovation itself, the communication channels, time and the social system. The tender is the factor which relates to every step in the innovation-decision process since it describes the wishes and requirements of the client and is related to regulations and legislations which directly affects the ability for a product innovation to be implemented. In the next paragraph the stimulants and barriers are derived from a qualitative desk research. They will define in more detail which relevant antecedents influence the upscaling of product innovations.

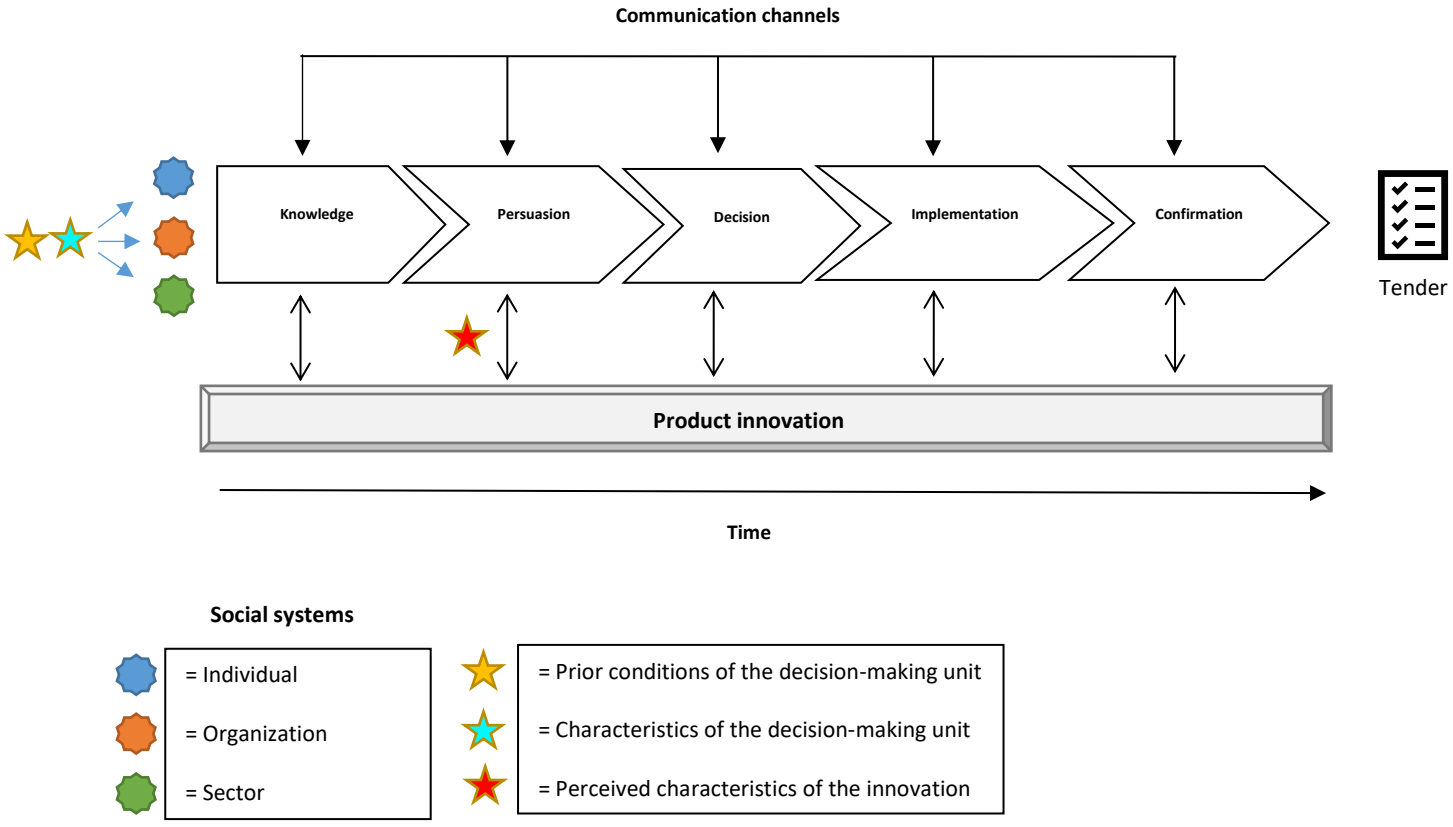


Figure 8. Model of influential factors for scaling up product innovations.

3.3 Stimulants upscaling product innovations

In the literature a lot of attention is given towards the adoption and diffusion of product innovations and the antecedents which are involved. A little is written about the actual upscaling phase which is essential as already discussed. A lot of different stimulants can be described during the whole innovation process which lead towards the diffusion, adoption, and continued adoption and implementation, the upscaling of the innovation. The attitude and choice of different key-decision makers who have to adopt an innovation differ in time but can also differ for each individual or organization. Therefore the stimulants of each phase are related directly towards the adoption rate and the success for product innovations to scale up. In general upscaling occurs when a majority, or a critical mass, of the members in a social system adopt and implement the innovation where it is then embedded as the dominant design at those companies. In this paragraph stimulants are described according to a couple of systematic reviews and articles related to different phases in the innovation process and the innovation-decision process. For describing the antecedents that are identified as influential the stimulants and in the next paragraph the barriers will be described according to 4 main categories as described by Vries, de, Bekkers, and Tummers (2015). They did a systematic review on antecedents of public sector innovation in 181 articles and books where 49% of the studies was related to product or service innovations which is the focus of this research. The 4 categories they described are:

1. Environmental level
2. Organizational level
3. Innovation level
4. Individual level

1. Environmental level:

The presence of environmental factors can stimulate the diffusion, adoption, implementation and upscaling of innovations. These factors often relate to the external context of which an organization needs to cope with. It changes wishes and requirements of public procurement and it can stimulate or push suppliers to cope with these factors by developing, adopting and implementing product innovations.

The first environmental factor which stimulates the upscaling of product innovation was stressed by Vries, de, et al. (2015) who described it as the ***environmental pressure*** including media attention, political demands and public demands. This especially market pull factor can stimulate the adoption and implementation of innovation and is therefore important for upscaling. In the health care sector for example these pressures can push the implementation of certain product innovations, stimulating upscaling to occur, (Fleuren, Paulussen and Wiefferink, 2012). It was also underlined by Cucciniello, Nasi, Mele, Valotti, and Bazurli (2015) saying that the responsiveness to public pressure is a significant determinant for the diffusion and adoption of innovations.

Hojnik and Ruzzier (2015) and Bossle, Barcellos, Biera, and Sauvee (2016) also stressed the ***environmental policy*** for eco-innovations as a stimulant for new innovations to be implemented.

Looking at public procurement on a broad level strategies and a vision are often formulated. But for product innovations to be scaled up it is important that the client describes ***clear requirements and wishes*** related to product innovations, (Fleuren et al., 2012). It is often unclear if product innovations can be applied and if so when and where. Both the environmental pressure and de needs of the client are market pull factors which are important drivers for innovations to be adopted and implemented.

The client can indirectly ask for innovations in terms of their relative advantage or directly in terms of a group of products for example different types of sustainable products also formulated as a stimulant by Edler et al. (2011), Bossle et al. (2016), and Hojnik and Ruzzier (2015). The importance and focus of a lot of studies towards eco-innovation was also underlined by the systematic review of Hojnik and Ruzzier (2015) and in the systematic review of Bossle et al. (2016).

When looking at a sector as a whole or a so called social system, ***inter-organizational relationships and participants in networks*** can influence individuals and organizations on their decision to adopt and implement an innovation where multiple decision-makers are absorbing and discussing relevant information. They start forming an attitude towards innovations which can lead towards decision-makers to actively seek information and social reinforcement in order to adopt and implement the innovation. These inter-organizational relationships and networks can therefore stimulate members of a social system in the adoption, implementation and so upscaling of product innovations, (Vries, de, et al., 2015); (Oirschot, van, Soonieus, Bake, and Kroon, 2010); (Fleuren et al., 2012); (Aarikka-Stenroos, Sandberg, and Lehtimäki, 2014); (Bossle et al., 2016).
Furthermore the ***regulatory aspects*** such as the procurement legislations and regulations where companies need to comply to can stimulate the use of products but can also inhibit the upscaling of these products, (Vries, de, et al., 2015). Bossle et al. (2016), and Hojnik and Ruzzier (2015) both saw in their literature review that regulatory pressures were the predominant driver for eco-innovations to be implemented.
Subsidies, grants and taxes can also stimulate product innovations for being adopted and implemented on the short term when companies have to invest a lot of resources which is often the case for radical innovations, (Hojnik and Ruzzier, 2015). It could make the innovation cheaper than the product it supersedes which is still an important aspect for an organization to invest in a product innovation or not.
Another external factor which can drive a product innovation to be scaled up is when ***compatible organizations adopt the same innovation***, (Vries, de, et al., 2015); (Oirschot, van, et al., 2010). The greater the number of compatible organizations in a sector the more likely they will adopt an innovation faster if a critical mass was acquired. The first question should be if all companies are indeed compatible and able to adopt and implement an innovation.
When discussing the sector the ***amount of competition*** can stimulate product innovations to be applied and therefore scaled up, (Vries, de, et al., 2015); (Oirschot, van, et al., 2010). When there is a large group of companies active in a certain sector the competition will be severe stimulating them to continually adopt and implement innovations in order to be competitive and viable.
Finally another stimulant for the adoption and upscaling of product innovations is the ***amount of similar innovations*** which are present. It can also stimulate the competition between companies bus will also increase the adoption rate, (Fleuren et al., 2012). It also gives more possibilities for the procurement body to buy product innovations since there is a level playing field which is not always the case especially for radical innovations due to their complexity. In appendix A1 the environmental stimulants are summarized together with their description.

2. Organizational level:

Stimulants to adopt and implement innovations are often very different for each company. Each of them can have their own structural and cultural features which are of influence. As mentioned before the type of innovation, incremental or radical, requires different resources and there are different stakeholders who all have to deal with the innovation. The next organizational stimulants can influence the adoption, implementation and upscaling of a product innovation.
The first stimulant combines a group or factors knowing the ***slack resources*** of an organization, (Vries, de, et al., 2015); (Fleuren et al., 2012). The company's size, personnel, knowledge, time and money are the most basic and valuable resources a company has to get inline. Where small organizations are often more flexible to change their working processes to adopt new innovations, the amount of personnel and the knowledge can stimulate the adoption speed whereas time and money are important for the ability and willingness to adopt and implement an innovation.
In relation to these slack resources in specific the financial resources are very important for companies. Not only if a company has money but also the wish and need to create more

financial advantages can be an important stimulant to scale up innovations. Cost savings or cost pressure are important drivers for the adoption of an innovation, especially for eco-innovations, (Hojnik and Ruzzier, 2015). Also the potential revenue is one of a product innovation's relative advantage which is very important for an organization's decision to scale up a product innovation.
When looking at the organization they can also stimulate their employees to seek innovations, get informed and use them. One way is through extrinsic motivation such as ***incentives and rewards***. Employees will be rewarded which can drive the upscaling of product innovations when they are stimulated to learn and adopt innovations.
Ryu (2015) also mentioned that the ***learning capability*** is a significant driver for technology commercialization and the performance especially for small- and medium-sized enterprises (SMEs). Vries, de, et al. (2015) also described it as the room for learning to be an important factor. SMEs often have scarcer resources and will have to make decisions whether to invest or not in a product innovation. It is not always due to unwillingness or disadvantages of a product. Furthermore learning-based capabilities help a company to acquire, absorb and assimilate knowledge to understand product innovations in order to apply them. Cucciniello et al. (2015) stressed the importance of organizational learning where e.g. training activities are important for the adoption, diffusion and upscaling phases.
The ***degree of risk aversion*** can also be an important stimulant, (Vries, de, et al., 2015). If this degree is low it can motivate and stimulate employees to learn, make mistakes and understand more about the innovation in order for a company to be able to cope with a product innovation. Vries, de, et al. (2015) mentioned that ***leadership styles*** such as political leadership and managerial leadership were strong determinants in the adoption of innovations. Where political leadership is especially focused on aspects such as sustainability and safety which stimulates certain types of innovations, managerial leadership is important for every type of innovation where a manager stimulates his/her employees, describes a mission and a strategy and puts resources into place. On the other hand especially for eco-innovations Hojnik and Ruzzier (2015) stressed ***top-management support*** to be a relevant driver for scaling up eco-innovations.
For the diffusion of innovations Oirschot, van, et al. (2010) described the importance of the ***norms, roles and social networks*** of an organization to be important. Norms, hierarchical structures, and informal networks of social systems can stimulate the innovation-decision process of their employees and the flexibility of the organization to adopt product innovations.
Looking at de demand-side Edler et al. (2011) mentioned the importance of the tenders which can directly or indirectly influence the potential of implementing and upscaling a product innovation. Especially via ***requirements in the award criteria*** of tenders product innovations can be stimulated to be applied. If requirements are met a fictive price discount could be rewarded which could lead towards winning a contract. Therefore it could be used to stimulate the upscaling of certain product innovations.
Also the ***size and duration of a contract*** can influence the choice of an organization to adopt and implement an innovation and the potential to scale up product innovations, (Edler et al., 2011). It can increase the return on investment of the company who applies the innovation due to the economy of scale advantages such as lower prices. It can also stimulate a procuring body to apply more in the same contract when the price drops.
Looking at the innovation-decision process ***early supplier involvement*** is a stimulant in a social system for an organization to adopt and finally implement an innovation knowing the supplier, contractor and/or client, (Hojnik and Ruzzier, 2015). It is essential to involve all relevant companies in an early stage so they can form an attitude, acquire knowledge, adopt the innovation and finally use it in future projects in order for the innovation to scale up. As mentioned it is important to know who is the product owner and if it is available for other contractors to buy and implement the product innovation.

Organizations can be described in terms of their innovativeness. A stimulant for the late majority to diffuse and adopt innovations is called ***isomorphism***, (Cucinniello et al., 2015). The late majority sees similarities in processes or structures to other companies who have already adopted the innovation which stimulates them to do the same. Oirschot, van, et al. (2010) described that the ***communication about the innovation*** is an important stimulant. The way people communicate, what information is communicated, how it is done and to whom determines how informed an individual is in the knowledge stage of the innovation-decision process. Looking more into the communication the ***degree of publicity to promote the innovation*** can stimulate an organization to seek more information and potentially apply it, (Fleuren et al., 2012). Hojnik and Ruzzier (2015) also described the ***company's image and reputation*** to be a driver especially for adopting eco-innovations.
Finally the last stimulant which was described by Hojnik and Ruzzier (2015) for an organization to scale up is ***the influence of the stakeholders***. In order for a product innovation to scale up it often needs social reinforcement and investments in different types of resources to successfully implement it in their working processes. All stakeholders have to make sure the infrastructure is put into place in order for the product innovation to scale up successfully. In appendix A2 the organizational stimulants are summarized together with their description.

3. **Innovation level:**

As Rogers (2003) described, the characteristics of a product innovation are important for the adoption, diffusion and upscaling of product innovations. Vries, de, et al. (2015) and Oirschot, van, et al. (2010) both stated that the ***relative advantage*** of a product innovation is a stimulant for upscaling. The relative advantage is often related to the needs of the client but they can also exceed the needs which can increase the adoption time. They are often related to economic, social or environmental advantages. Vries, de, et al. (2015) and Oirschot et al. (2010) mentioned the cost advantages and the financial feasibility as stimulants to adopt and scale up an innovation. Cost advantages to purchase an innovation, maintenance costs, lower life cycle costs, all important relative advantages which differ between products but are an important driver, (Hojnik and Ruzzier, 2015). Social advantages such as the importance for users are not always measurable such as the safety feeling which could differ for each user. Looking at the environmental factor Dutch and European politicians agreed that an innovation should focus on sustainability where the type of materials, carbon dioxide, and the recycle potential are examples which are important for innovations in order to be applied and scaled up in the future. Other characteristics which were also mentioned by Rogers (2003) which are stimulants in the adoption and diffusion of a product innovation are the ***compatibility, complexity, trialability, and the observability.*** The complexity was described as how easy it is to use, especially for the adopters and the users. Furthermore the observability also relates to the trustworthiness and the evidence of the outcomes which can stimulate the adoption of an innovation.
Another stimulant to adopt, diffuse and especially apply an innovation is when the product innovation is based upon ***open technical standards*** to support it. If the knowledge and information on the basics are already available in the market it is more likely that an innovation will be embedded as the dominant design, (Oirschot, van, et al., 2010). It often leads towards the ***standardisation of the technology*** meaning a technology is integrated as a dominant design which increases the upscaling of a product innovation, (Oirschot, van, et al., 2010). It could especially be important for radical innovations whereas these require more know-how and training when the technology is new to most members of the social system. If knowledge is spread and the innovation will eventually become embedded as a dominant design upscaling will occur more likely. In appendix A3 the innovation level stimulants are summarized together with their description.

4. **Individual level:**

When looking at the stimulants on an individual level, also the potential key-decision maker, he or she can be the adopter of a product innovation within an organization. One person can have a great influence on adopting, implementing and therefore the upscaling of a product innovation in their own company or could influence other companies' to adopt and apply it. First of all the ***employee autonomy*** or the empowerment can be a stimulant when an individual is actively seeking for innovations and gets informed, (Vries, de et al., 2015). Other factors especially described as stimulants by Vries, de, et al. (2015) are ***job-related skills, creativity, and commitment.*** An individual who is very intelligent, professional and has a lot of job-related skills is often more inclined to adopt an innovation faster and therefore to increase the adoption rate. Creativity also relates to solving problems, having an open mind, and in some sense to be more risk-taking which can stimulate the adoption, diffusion and upscaling of a product innovation. Commitment can be described in a broad sense for example commitment to get the lowest costs or best environment-friendly product. Other individual stimulants for the upscaling of a product innovation are the ***job satisfaction*** and the ***shared perspectives and norms***, (Vries, de, et al., 2015). It can stimulate the willingness of an individual to learn more about the innovation but also to communicate with others to get a positive attitude. Oirschot, van, et al. (2010) also described the type of person in a group to be an important factor that can stimulate the adoption and implementation. These so called ***homogeneous groups*** have comparable characteristics which stimulates the diffusion and adoption within a group. Finally the ***innovativeness*** as Rogers (2003) described it earlier is the degree to which people easily adopt and implement innovations in an early stage. If the employee is for example an innovator it could stimulate the adoption, implementation and therefore upscaling of a product innovation. In appendix A4 the individual level stimulants are summarized together with their description.

3.4 Barriers upscaling product innovations

This study proposes barriers that prevent or inhibit the upscaling of product innovations. It focuses on a broad perspective knowing different sectors and countries will be taken into account. They will be specified in the next chapters to see what they mean for the contractors in the construction industry and how RWS could change or influence these barriers. When looking at the innovation process and in particular the upscaling process, which was defined as the TRL-10, it comes to the attention that some product innovations which are applied successfully for the first time in a project lack broad implementation. As Rogers (2003) explained the continued adoption and implementation of an innovation needs all key decision-makers within a social system to undergo the knowledge, persuasion, decision, implementation and confirmation steps. For individuals, organisations and even a whole sector different barriers can occur over time and differ in each tender in order for a product innovation to be implemented again. Via literature reviews and studies barriers are described on an environmental, organizational, innovation and individual level which are related directly or indirectly towards the upscaling of a product innovation.

1. **Environmental level:**

On an environmental level there are several barriers which can prevent a product innovation to be applied even if it was already applied once by an organization. The external context is very broad and includes all things from a political level to product regulations.
Important barriers often described in research to scale up product innovations are the ***legislations and regulations,*** (Fleuren et al., 2012); (Vries, de, et al., 2015). These often prevent innovations to be implemented even if they were applied in a project before. It can be related to a company's business activities, the procurement process or just the product itself. It doesn't necessarily mean the product innovation is able to be applied in every project. Also the pressure of the European Union can influence these legislations and regulations and can result in a certain ***social importance to scale up*** or not to scale up, (Fleuren et al., 2012). If an innovation is not accepted and described as important on a higher political level it could form a barrier for product innovations to scale up.

If a product innovation isn't restricted to be applied there is also another barrier for scaling up product innovations which can be described as the ***lack of demand for innovation from the procuring body,*** (Edler et al., 2011). It describes the needs and wishes in a sector which could prevent innovations from being implemented again if it is not described in all relevant tenders where an innovation could be applied since it can differ for each project.
Within the sector ***fragmentation of the industry and professional bodies*** is described as a barrier, (Kulatunga, Amaratunga, and Haigh, 2006). They also stressed that the ***isolation between contractors and engineering- and consultancy firms*** are a barrier for innovations to scale up. It could prevent product innovations to be embedded as the dominant design and therefore prevent upscaling. When looking at the professions and specialisms in a sector it can be a very important issue for innovation to scale up when it has ***significant coordination and integration problems,*** (Kulatunga et al., 2006). When there are a lot of specialists who all need to work together including all the stakeholders it can be a barrier to scale up a product innovation or decrease the pace in which it is scaled up if there is no clear consensus and coordination. Cucciniello et al. (2015) also described ***traditional channels of political communication*** as a barrier to innovations.
Another impeding factor is the amount of companies which are active in a sector. It affects the ***amount of competition*** and therefore indirectly the need for an organization to apply and scale up innovations in order for a company to be competitive and win tenders, (Vries, de, et al., 2015). In appendix A5 the environmental barriers are summarized together with their description.

2. Organizational level:

On an organizational level barriers to adopt and implement an innovation can differ between each company and can therefore prevent upscaling of a product innovation. Each organization has its own cultural and structural characteristics which can be a barrier for product innovations to be applied but also to be scaled up due to a lack of resources. One of the barriers described is a lack of ***clear requirements and wishes of the client***. It isn't always clear if a product innovation can be applied in future projects, (Fleuren et al., 2012). Edler et al. (2011) discusses in his review, where a majority of the companies find it a very significant barrier, that ***price is more important than quality***. Often there are few incentives for contractors to apply an innovation if it is not in a way cheaper meaning that quality of a product is less relevant if the price is not equal or lower than the product it replaces. This is especially important for products which comprises a large amount of the total price compared to other small products which have less effect on the total price.
Furthermore Edler et al. (2011) find that the former barrier was linked towards the ***degree of risk aversion*** also described as a barrier by Vries, de, et al. (2015)***.*** A high degree of risk aversion leaded in avoiding risks, less learning from mistakes and less adoption of product innovations which have some uncertainty. Especially for the supplier but also for the client who could evade risks in tenders. They often just use regulations and legislations to avoid risks and create a qualitative and safe product. Ryu (2015) and Cucciniello et al. (2015) specifically named the ***learning capability*** as a barrier especially focusing on SMEs in order for an innovation to be commercialized. It was reflected to the organization's daily activity and procedures to handle knowledge in such a way it ultimately will be their own capability. If an organization is unable to learn it will be hard for product innovations to be applied and eventually prevent upscaling to occur.
For the diffusion of innovations Oirschot, van, et al. (2010) described ***norms, roles and social networks*** as important barriers. For instance hierarchical structures can take time and hinder upscaling. Also a small social network decreases the potential of knowledge acquisition, assimilation and qualitative peer discussions. A ***lack of management support*** is therefore also an important barrier for product innovations to be applied and scaled up, (Long, Blok, and Coninx, 2016). Uyarra, Edler, Garcia-Estevez, Georghiou, and Yeow (2014) also mentioned ***poor management of risk*** to be an important barrier. Vries, de, et al. (2015) and Fleuren et al. (2012) stresses that ***slack resources*** as mentioned to be a stimulant are more often a barrier for scaling up innovation whereas a lack of knowledge, personnel, time,

and/or money can occur. Especially for SMEs it is an important aspect of their decision to adopt and implement a product innovation.
Especially the ***financial disadvantages*** were described in a lot of research to act as a barrier in order to adopt, implement and scale up product innovations, (Oirschot, van, et al., 2010); (Fleuren et al., 2012). Cucciniello et al. (2015) described that the implementation costs for a product innovation are a barrier to scale up. Long et al. (2016) described competing financial priorities, long pay-back periods, and uncertain returns as barriers. The last barrier can also be related again towards the market potential and a lack of clear wishes and requirements of the client in future projects.
When discussing the client a barrier for scaling up innovations was described as a ***lack of interaction with the procuring body***, (Edler et al., 2011). When done properly, the procuring body could get insight information from the market on the table which barriers to overcome, risks to manage and so on. On the other hand there is also a lack on feedback from the procurement process which could result in the rejection of an innovation in the future.
Another barrier related to public procurement mentioned by Edler et al. (2011) is that the ***procurement process is overly complex***. Together with Uyarra et al. (2014) they also mentioned that the ***size and duration of contracts*** can also form a hinder. Especially for small- and medium sized companies who have fewer resources and experience with large contracts it is hard to grasp and comply to the procurement process and its regulations. The size and duration can make it even harder for these companies to even take part due to references, capacity issues, resources and high risks. Therefore some product innovations could eventually not be applied at all and therefore upscaling will not take place.
The ***size of the company*** can also influence the flexibility and the possibility to adopt and implement product innovations on a broad scale, (Fleuren et al., 2012); (Cuciniello et al., 2015). For larger organizations it is harder to adjust and adopt innovations rather quickly. Vries, de, et al. (2015) also described the ***structure of an organization*** to be relevant where the hierarchical structure could make a company less flexible and able to adopt innovations. Important are the ***organization and industry culture*** which can prevent innovations to be applied on a broad scale especially when there is a lack of social importance or stimulants from important stakeholders to do so, (Kulatunga et al., 2006). If the product innovation doesn't comply to the beliefs of an organization it could also be rejected by some companies. Finally a stimulant but also a barrier is the ***influence of stakeholders***. They can prevent innovations to be applied or scaled up when they are not able or willing to cope with the new product innovation. In appendix A6 the organizational barriers are summarized together with their description.

3. Innovation level:

When looking at the 5 characteristics of an innovation as described by Rogers (2003) they were described as stimulants. On the contrary some of them are especially seen as a barrier to implement and scale up a product innovation. First of all the ***complexity*** of a product innovation could be a barrier. If the product is very complex, often the case for radical innovations, it could lead to a competence-destroying situation and high investments for a company which is not always desirable. Also if it isn't easy to understand and easy to use the complexity can result in a barrier to scale up an innovation, (Rogers, 2003). Vries, de, et al. (2015) and Long et al. (2016) also described the ***trialability*** and ***observability*** as barriers. If a product was successfully applied for the first time but other companies are not able to try the product innovation or observe how it was tested and implemented it can prevent upscaling to occur. Also a lack of ***scientific support of an innovation*** can withhold contractors to apply and scale up an innovation although it is once successfully applied, (Fleuren et al., 2012). It means that the product isn't integrated as the dominant design but has some uncertainties or risks which prevents adoption and implementation to take place.
When looking at the demand of the client, its ***prescriptive specifications*** can hinder innovations to be applied again especially when they are more rigid than for example

outcome-based specifications, (Uyarra et al., 2014). Especially rigid technical regulations restrict innovations to be applied in for example the construction industry, (Kulatunga et al., 2006). These specifications can also result in risk aversion due to the long life span of the product. On itself the ***life span/capital life*** of a product, especially those of the current technological stock, is a barrier for new product innovations to be scaled up, (Long et al., 2016). Many products have different life spans which make it hard to just replace them especially when they are part of a CoPS. A low life span is also a barrier related to the return on investment and the total cost of ownership. It decreases the willingness of companies to adopt and implement the product innovation and can therefore prevent upscaling to occur. On the other hand the question is whether the life span of a product innovation should be long whereas it decreases the possibility to apply innovations in the near future. In appendix A7 the innovation level barriers are summarized together with their description.

4. **Individual level:**

The potential key-decision makers can withhold a product innovation to be applied (again). A person can have a great influence on adopting, implementing and therefore scaling up of a product innovation in their own company or even influence other individuals in their social network.
As Rogers (2003) mentioned the ***innovativeness*** of these individuals, the type of adopters, determine the pace of which an innovation is or isn't adopted and therefore scaled up in an organization. The late majority and laggards in general need more time before they will adopt and implement an innovation and can therefore prevent upscaling in an early stage. They will often wait until the majority of a group already adopted the innovation, (Rogers, 2003).
As discussed upscaling occurs when a product innovation gets from a niche solution towards a mainstream solution. It also means individuals have to develop know-how and therefore change or complement part of their competences and habits. Edler et al. (2011) described it as the ***lack of capabilities*** where an employee lacks experience, knowledge or interest in a certain product innovation withholding the person to adopt and implement a product innovation. It could also be imposed by the management not to take risks. ***The perceived risk aversion*** could also be a personal characteristic influencing the upscaling of a product innovation, (Edler et al., 2011). Oirschot, van, et al. (2010) described the type of persons in a group to be a barrier. In contradiction to homogeneous groups, ***heterogeneous groups*** have different characteristics and can form a barrier to scale up innovations or at least reduce the time to adopt and implement innovations whereas they often have discussions among each other. In general ***behavioural/psychological*** barriers are important in forming a positive or negative attitude towards adopting, diffusion and scaling up innovations, (Long et al., 2016). As mentioned before in the model of Rogers these have to be taken into account but will have to be described in more detail in further research. In appendix A8 the individual level barriers are summarized together with their description.

Vries, de, et al. (2015) concluded that looking at the innovation process the innovation level was the most relevant in literature studies looking at the adoption and diffusion. The environmental, organizational and individual level where focused on both the generation stage of the innovation as well as the adoption and diffusion stages. Looking at the relationship between innovation types and antecedents in the public sector the organizational antecedents play the largest role in enabling all innovation types, (Vries, de, et al., 2015). For product innovations environmental and organizational antecedents were the most important factors before innovation characteristics and individual antecedents. A side note have to be made because the adoption, implementation and upscaling of a product innovation needs to be accepted not only by the supplier and/or other contractors but also by the client, the user and other possible stakeholders.

3.5 Conclusion

Looking at the factors that influence the upscaling of product innovations it is a continually changing process over time which also differs between key decision-makers such as an individual or even an organization. The most important factors are related to the diffusion of an innovation and the innovation-decision process where a social system (individual, organization or sector) makes a decision whether to adopt, continually adopt and implement a product innovation. Each factor of the diffusion process will be shortly described plus the tender as an influential factor and how they influence the upscaling process. Finally the antecedents related to each step of the innovation-decision process are described to create an overview.

Innovation
The product innovation is related to each step of the innovation-decision process. In the knowledge stage members of the social system have to be informed about the innovation to create a positive or negative attitude before starting activities to learn more about the innovation in the decision-stage. Awareness-, how to-, and principles knowledge are important to communicate towards the relevant members of a social system. The perceived characteristics of a product innovation are important in forming an attitude. The relative advantage, complexity, compatibility, trialability and observability are the most important characteristics described by Rogers (2003). These relative advantages (added value) are important for the supplier and/or contractor but also for the client who all have different goals related to the innovation. After a decision was made the social system starts to acquire operational information before it can be implemented. Finally in the confirmation stage it could very well be that the innovation has to be re-invented towards other project specific requirements or new regulations and legislations. The innovation should therefore be analysed continually to look at changing aspects in the innovation-decision process for different members of the social system.
The availability of a product innovation is important for adopters of the innovation. If a product isn't sold, diffusion will only take place towards the client(s) and upscaling will most likely not occur. If the underlying technology of a product innovation is available for all companies the adoption and implementation of a product innovation is more likely to take place. Standardisation is a stimulant for upscaling since a product innovation can (needs to) be embedded as the dominant design. On the contrary standardisation prevents other product innovations to be developed, applied and scaled up.
Finally if a product innovation can easily replace the current product that was used the adoption rate is faster whereas a CoPS will probably take longer and require multiple stakeholders to be convinced.

Communication channels
Since each member of a social system has different prior knowledge, experiences and characteristics different communication channels can stimulate the information assimilation and discussion with peers. It is important to inform them and to reduce uncertainties. Different channels can be used for different steps of the innovation-decision process where social media and professional journals for example can be useful in the knowledge stage. For the decision- and implementation stage face-to-face meetings are implied to be most effective.

Time
Since environmental- and organizational factors are continually changing and product innovations have to comply to different and changing needs of members of a social system, the innovation-decision process differ over time and needs continuous attention.

Social system
The members of a social system are a set of interrelated units who want to achieve a common goal. It is important to understand the different needs and wishes of not only the client(s) but also other contractors and stakeholders. A contractor can have their own innovation strategy and goals which doesn't have to level directly to a product innovation. It is important to understand all these different needs and wishes in order for a product innovation to be diffused, adopted, implemented and scaled up.

Tender
Each tender is unique and describes different needs and wishes. It can stimulate or prevent upscaling to occur. In the tender the client can give space for a product innovation to be applied. Especially if specifications are more functionally described instead of technically. A tender can also stimulate a product innovation indirectly in terms of its relative advantage via a fictive price discount. It can also ask directly when standardisation of the underlying technology is described. Regulations and legislations have to be analysed in order to see if they prevent the implementation of a product innovation in other projects. The size and duration of a tender can also influence the adoption and implementation of a product innovation whereas it can stimulate the financial advantages such as cost reduction, return on investment and profit.

Innovation-decision process
Looking at the decision-making units, prior conditions and characteristics differ between client(s) and contractors. Antecedents are described, with all the stimulants (+) and barriers (-), in relationship to each step of the innovation-decision process, see table 3.
It is important to underline that there was no scientific research that described these barriers and stimulants directly towards the 5 steps of the innovation-decision process. They are interpreted and described as much as possible from the context of the research. It can also differ between members of the social systems and between product innovations. Further research should focus on specific product innovations in different tenders to see which barriers and stimulants are influencing each stage of the innovation-decision process.

	Knowledge	Persuasion	Decision	Implementation	Confirmation
Environmental antecedents					
The environmental pressure and policy	+/-	+/-	+/-	+/-	+/-
Regulations and legislations	+/-	+/-	+/-	+/-	+/-
Requirements and wishes (demand)	+/-	+/-	+/-	+/-	+/-
Inter-organizational relationships	+		+	+	
Compatibility of organizations adopting the same innovation			+	+	
Fragmentation of the industry and professional bodies	-		-	-	
Collaboration between contractors and engineering & consultancy firms	-		-	-	
Coordination and integration between companies in the market	-		-	-	
Traditional channels of political communication	-				
Financial aspects	+/-	+/-	+/-	+/-	+/-
The amount of competition	+/-		+/-	+/-	+/-
The amount of similar products	+		+	+	+
Organizational antecedents					

Slack resources	+/-	+/-	+/-	+/-	+/-
Financial impact	+/-	+/-	+/-	+/-	+/-
Incentives and rewards	+	+	+	+	+
The learning capability	+/-	+/-	+/-	+/-	+/-
Degree of risk aversion	+/-	+/-	+/-	+/-	+/-
Leadership style and support	+/-	+/-	+/-	+/-	+/-
Norms, roles and social networks	+/-	+/-	+/-	+/-	+/-
The contract (size, duration, specifications and award criteria)	+/-	+/-	+/-	+/-	+/-
Communication with the procuring body	-	-	-	-	-
Isomorphism			+	+	
Communication about the innovation	+	+	+	+	+
Degree of publicity of an innovation	+	+	+		
Company's image and reputation	+	+	+	+	+
Influence of stakeholders	+/-	+/-	+/-	+/-	+/-
The procurement process			-	-	-
Requirement and wishes	+/-	+/-	+/-	+/-	+/-
Price compared to quality			-	-	-
Organization- and industry culture	-	-	-	-	-
Innovation level antecedents					
Relative advantage		+/-	+/-	+/-	
Complexity		+/-	+/-	+/-	+/-
Compatibility		+	+	+	+
Trialability		+/-	+/-	+/-	
Observability		+/-	+/-	+/-	
Availability of the technology		+/-	+/-	+/-	
Standardisation of the technology	+	+	+	+	+
Specifications in the tender	-	-	-	-	-
Individual level antecedents					
Employee autonomy	+		+	+	+
Capabilities	-	-	-	-	-
Creativity	+	+	+	+	+
Risk aversion	-	-	-	-	-
Commitment	+	+	+	+	+
Job satisfaction	+	+	+	+	
Shared perspectives and norms	+	+	+	+	
Types of groups the individual is in			+/-	+/-	
Innovativeness	+/-	+/-	+/-	+/-	
Behavioural/psychological factors	+/-	+/-	+/-	+/-	

Table 3. Antecedents, stimulants (+) and barriers (-), and the innovation-decision process.

Chapter 4. Road construction industry and scaling up product innovations

4.1 Introduction

Road construction in this research can be defined as new constructions and maintenance activities on the road network in the Netherlands, (Groot, Afrian, Hardeman, and Vrolijk, 2012). It includes new roads, reconstruction, replacement as well as the maintenance. It is managed by RWS, municipalities, provinces and water authorities (in Dutch: Waterschappen). To create a better understanding of the context in which product innovations are being implemented the current situation of the road construction industry in general, the trends and outlook, and the current status quo of product innovations in the industry are described to get an understanding on how these can influence upscaling. This will be important in order to answer the main research question on how RWS can influence the upscaling of product innovations and to what extent the construction industry influences it.

4.2 Current situation

In the Netherlands there is around 139 thousand kilometres (km) of road. It is managed by the state, provinces and municipalities. The state roads are managed by the ministry of I&E together with RWS as the executive body which includes 5357 km of the 139.294 km in total which is only 3.85%. The provincial roads includes 7757 km which is 5.57% of the total where the largest amount of km are managed by municipalities which have a total of 126.180 km which is 90.58%. In figure 9 below you can already see how high the density of the Dutch road network is where it only shows the state roads (red) and provincial roads (yellow) which only cover 9.42% of the total road network, (Centraal Bureau voor de Statistiek, 2017).

Figure 9. The Dutch main road network in 2016.

In 2011 there were 230 road construction companies who were a member of Bouwend Nederland, one of the largest entrepreneurial organizations for construction and infrastructure, (Groot et al., 2012). Together they have a turnover of 4.5 billion euro in 2011 with a total amount of 18,000 employees. They divided these organizations in general road construction companies and specialist road construction companies. The general road construction companies carry out all the activities that occur form the construction and maintenance of the road infrastructure whereas the specialist road construction companies are specialized in work on the road such as milling, markings, the installation of a guide rail or the installation of noise barriers.
The 195 companies active in the general road construction industry had 14,450 employees and a turnover of 3.8 billion euro in 2011 of which 50% was realised by the large companies, 25% by middle and 25% by small companies. The large companies are defined as companies with a turnover of over 150 million euro which are only 10 companies within the Netherlands (5.13% of all 195 companies). The medium companies, 25 in total, had a turnover between 15 and 150 million euro (12.82%) and 160 small companies with a turnover less than 15 million euro (82.05%). From the total turnover of the general road construction companies 70% was derived from the government of which the municipalities were the biggest clients.
The specialist road construction companies had a turnover of 750 million euro in 2011 where 35 companies together with 3,500 employees were active which was realised for 50% within integral projects often done by sister companies or sub-contractors, (Groot et al., 2012). Looking at the size of the projects larger than 5 million euro small companies did not compete. It is also remarkable that large companies also achieved 23% of their turnover from small projects, below 0.5 million euro and that they have the largest part of their turnover acquired from projects below 20 million euro.

The type of contracts used especially for municipalities still have a traditional form knowing the RAW contracts which covers 80% of the turnover for small companies and 55% of the turnover for medium sized companies.
In the last years though there is a tendency that there are more integrated contracts meaning that within 1 contract the whole trajectory from design until managing and maintaining a road is included. The problem according to construction companies is that the way it has to be executed often is already determined and that there are high development costs. Larger projects often have high reference requirements in their tendering policy which excludes a lot of companies to compete. It results in more collaboration between companies (competitors) in consortia especially for SMEs with large contractors who want to participate in large projects. Groot et al. (2012) also concluded in their research some bottlenecks between the client-contractor relationship within the road construction industry. The most important ones were the lack of space for the market, lack of trust and lack of knowledge from the client. But also the distribution of risks and responsibilities were mentioned to be bottlenecks in the client-contractor's relationship.

The infrastructure in the Netherlands has some great challenges to tackle in the coming years. Due to demographic, economic and technical developments the demand for infrastructural projects has raised for the next decades. For the period till 2030 it is estimated at 250 billion euro including all types of infrastructure. For the road construction industry new bottlenecks in the existing infrastructure are present where expansion is often necessary. The roads build in the 60s and 70s will need to be replaced, reconstructed and/or broaden. Not only the amount of infrastructure will increase but also the quality of the networks is important. It goes beyond the individual qualities for the users such as the availability and reliability of the networks but also the social desires such as sustainability and safety. In the next paragraph the trends and outlook of the construction industry is described to see where the industry needs to concentrate on and where innovation plays a role.

4.3 Trends and outlook

The road construction industry will have some challenges and questions that need to be answered in the coming future. Especially when looking at product innovations and how to implement them in future projects. Trends are long-term developments which already occur and how they are expected to look like in the future. The described points were derived from the report of Bouwend Nederland with their outlook towards the construction industry in general in 2020. The trends Rabobank describes for the GWW from a more financial point of view together with general observations specifying some more on the road construction industry. Additionally information from the Pianoo will be used, which is an expertise centre for tendering of the ministry of Economic Affairs and Climate, and a report of the Economic Institute for the Construction industry focusing on innovations in the road construction industry in the Netherlands.
To describe the developments in the market of the construction industry in a simple way the DESTEP-method is used. It looks at 6 different areas: demographical, economic, social-cultural, technical, ecological and political.

Demographical:

The demographical factors will describe the Dutch population which can be important for the whole sector in different ways such as influencing the labour market or the clients/users in an industry. These are important since they can influence the demand for road construction projects but also the wishes within these projects for the users. Furthermore the labour market can influence the upscaling of product innovations. An increase or decrease of highly qualified personnel can affect organizations to cope with innovations and therefore the implementation and upscaling of it.

- ***Ageing and degeneration***
  Ageing and degeneration will influence the labour market in both quantity as well as quality. It can make companies less flexible and able to cope with new innovations whereas the new and young generation often have more basic skills and knowledge towards (new) innovations, (Bouwend Nederland, 2012).
  Rabobank also formulated that ageing and a low influx of young people are forming a threat for companies, (Rabobank Cijfers & Trends: Aannemersbedrijven grond-, water- en wegenbouw, n.d.).
  Arnoldussen, Groot, Halman and Zwet, van (2017) also described these factors to be important resulting in a higher demand for personnel. In order to solve these issues automatization and robotization are expected to grow in the coming years and will increase product- and process innovations to be developed and implemented.

- ***Increasing urbanization***
  In the Netherlands there is a large increase of inhabitants in the large cities, especially in the Randstad leading to a higher density of the traffic flow and more complex solutions due to the lack of space and environmental issues that need to be dealt with. It will also increase market opportunities for large projects and innovative and sustainable solutions, (Arnoldussen et al., 2017).

Economic:

The economic factor relates to trends influencing the purchasing power and spending patterns in the industry. It also influences the possibility and probability for organizations to invest in resources. Therefore it can affect organizations to be willing and able to implement innovations.

- ***Increasing internationalisation***
  Due to an increase in the urbanisation and globalisation a lot of investments in the

construction industry in upcoming markets will take place such as Asia, Latin America and the Middle East. Also in Europe a tendency is seen towards European companies taking over other countries' projects besides their own where Denmark and Sweden are both good examples. The international playing field is therefore expected to increase. It creates opportunities where a product innovation could be implemented in more countries, increasing upscaling but also the return on investment of a product innovation. Since the competition will be more severe it is also a threat for Dutch construction companies. Another opportunity of internationalization for companies is to buy more materials, equipment, knowledge and craftmanship abroad, (Arnoldussen et al., 2017). The latter is important as ageing and degeneration in the Netherlands increases.

- ***Private investors***
  Private investors have more interest in infrastructural projects with emphasis on the road construction projects, (Pianoo: Marktbeschrijving GWW, n.d.). It can create opportunities for companies to finance projects instead of collaborating with other competitors in consortia.

- ***Middle- and long-term prospects***
  The economy on the middle- and long-term is very questionable. Therefore the prices of labour, raw materials but also the investment in product innovations are not self-evident, (Bouwend Nederland, 2012). Rabobank also describes the lack of large long-term infrastructural projects in the future to be an important trend, (Rabobank Cijfers & Trends: Aannemersbedrijven grond-, water- en wegenbouw, n.d.). It can make companies cautious in spending their financial resources focusing more on some innovations with a high relative advantage. Nevertheless until 2030 it is expected that there will be 250 billion euros invested in the infrastructure as a whole, (Groot et al., 2012).

- ***Financial- and contractual options***
  The financial- and contractual options are becoming more complex especially for large projects, (Bouwend Nederland, 2012). It has a great disadvantage for large organizations and especially SME's. More time and money have to be invested in order to compete for large construction projects. These high tendering costs have to be made without the certainty of winning the contract. It could therefore pressure the purchasing power and change the spending patterns of construction companies.

- ***Scale reduction – diversification***
  Scale reduction occurs due to the diversification of the client's demands. Some large projects are divided into several smaller tenders, (Bouwend Nederland, 2012). It results in more opportunities for SME's and more competition on projects for the large construction companies.

- ***Scale enlargement - consolidation***
  In the infrastructure consolidation of companies is increasing and therefore small companies disappear and the larger companies become even larger, (Bouwend Nederland, 2012). They will be incorporated or will continue as a subsidiary from a medium- or especially large construction company giving them more power.

- ***Scale enlargement - clustering***
  On the other hand small projects are more and more clustered in contrary to the diversification of the large projects, (Rabobank Cijfers & Trends: Aannemersbedrijven grond-, water- en wegenbouw, n.d.). This would result in a disadvantage for especially the small but also the medium sized construction companies.

- ***Niche markets***
  The amount of niche markets are increasing and therefore the amount of companies with exclusive skills, (Bouwend Nederland, 2012). This amount will probably increase due to new technologies and innovations such as automatization and digitalization. The general construction companies lack competences to cope with these developments or simply just focus on their core competences.

Social-cultural:

Are the trends which influence the society's wishes, demands, values and behaviour. These are not only important for the users in the construction industry but also all stakeholders in the industry. These can stimulate or prevent upscaling of innovations to occur if not all stakeholders have the same goals and vision in mind.

- ***Social Media***
  Social media is still increasing and is becoming more important in the construction industry. This is not only useful for marketing purposes but also spreading information and making the sector more transparent. It offers opportunities for the positioning of products, services and the company itself, (Bouwend Nederland, 2012). It is also important in the way residents in a construction area are informed and can give potential buyers of visualization and insight information of a product innovation which was applied in a project. It is therefore especially useful in the knowledge- and persuasion stage of the innovation-decision process.

- ***Company's culture***
  The culture of the company is changing towards a company which is focusing more on sustainability, (Bouwend Nederland, 2012). It changes the whole road construction industry and is changing competences and processes. Some focus areas will be elaborated under the ecological development paragraph.

Technical:

These factors relate to new and existing products and market opportunities. They can change the demands and wishes of the client and the contractor. The contractor and the client have to deal with these technological trends in order to integrate them into their working processes.

- ***Standardisation***
  Standardisation is becoming more common practice. Not only prefabrication but also diversification within the standardisation with focus on sustainability, (Bouwend Nederland, 2012); (Pianoo: Marktbeschrijving GWW, n.d.).

- ***Information- and communication technology (ICT)***
  ICT will continue to grow which increases the pace of the industry to automate, (Bouwend Nederland, 2012). A good example is the Building Information Model called the BIM. Every building phase of a road, bridge or sewer can be simulated and reviewed on forehand. With existing and new data it can create different scenario's in the design phase where it can even be tested and visualized reducing risks and failure costs. You can manage the construction site and it is even possible to add a time and financial dimension.

- ***Innovation and re-use of materials***
  Innovation and renewing construction materials will stay important, (Bouwend Nederland, 2012).
  Arnoldussen et al. (2017) described some more specific trends on new and existing technologies which will have an impact on the road construction industry. It means all

stakeholders have different roles in the future in coping with these developments. Some of the most important technological developments and/or innovations are described:

- ***3D-printing***
  A machine that can make objects with digital designs by building it layer by layer. It will impact the way products are produced, can solve maintenance issues, and can increase the technical life span of products.

- ***Robotics***
  The use of robots for all types of functions, from manufacturing to service-oriented applications. It will change the supply chain from the way products are produced, the implementation, quality control, maintenance and so on. It can have a very large impact for all companies in the supply chain.

- ***Internet of Things***
  Objects are connected to each other via the internet. It can give real-time information of products, traffic situations, monitoring et cetera. The exchange of data can especially help during the realisation and exploitation stages of a construction project.

- ***Augmented reality***
  It gives the opportunity to get a direct or indirect image of the reality where a computer can even add elements. It gives the possibility to educate and train employees in different circumstances without being on the site. Robots can even be connected with augmented reality via Internet of Things to do maintenance for example.

- ***CNC technique***
  Computerized operation of machine tools which can modify different types of materials such as metal and wood in a rather fast and precise way. It decreases the need for real craftmanship and can increase the productivity and quality level of a product.

- ***Big data***
  Large amounts of real-time data are analysed which are acquired from structural and non-structural sources. The data can be used to make predictions on which products in a certain area need to be replaced at a certain moment of time. It can optimize maintenance operations and can influence the planning- and design phase of a road construction project since data is already available.

- ***Smart materials***
  Materials all have their own characteristics. New products are being developed which are able to undergo major changes in their shape due to external influences such as the amount of load, temperature, humidity, acidity (pH), electric- or magnetic fields.

- ***Design modules***
  Modules are used where a client or contractor for example can compose a design themselves from a pre-programmed set of variations.

- ***Self-healing materials***
  Materials which have the ability to heal after being damaged by mechanical use. Damaged roads can be repaired with self-healing materials which increases the life span of the product.

- ***Drones***
  These unmanned aerial vehicles can help in different situations especially for the inspection of bridges to measure the quality and see if direct action is necessary.

- ***Chips, sensors and RFID***
  These can store and send information and/or can operate products remotely. It can be a solution for predictive and corrective maintenance and can be used as input for big data.

Ecological:

Trends related to environmental aspects are increasing the last decades. It will influence products, the way companies work and what clients and users demand. It can stimulate upscaling of product innovations that are more sustainable than the product it supersedes.

- ***Sustainability***
  The government, provinces, municipalities and water authorities are focusing more on sustainability. It means goals are set in order to reach e.g. Horizon 2020. It relates to the construction process, the product, the material as well as coping with environmental factors, (Bouwend Nederland, 2012); (Pianoo: Marktbeschrijving GWW, n.d.); (Rabobank Cijfers & Trends: Aannemersbedrijven grond-, water- en wegenbouw, n.d.).
  In the climate conference in Paris in 2015 another goal was described. In 2050 the building environment should be energy-neutral which will lead towards investments in technologies and new process- and product innovations, (Arnoldussen et al., 2017).

- ***Renewable raw materials and energy***
  The climate change especially focuses on renewable raw materials and energy, (Bouwend Nederland, 2012); (Rabobank Cijfers & Trends: Aannemersbedrijven grond-, water- en wegenbouw, n.d.). Recycling and the use of secondary raw materials are becoming more important which will have to be taken into account in the design. It can decrease the costs of the client and supplier but will also have an impact on the way manufacturers/suppliers earn money.

- ***Circular economy***
  The circular economy is becoming more important meaning the product's lifecycle doesn't end after it is used. The components of a product should be able to be applied again with the same or even a higher quality level as a result. It leads to less raw materials needed and the ability to re-use materials after their technical life span. It also results towards the demand that products need to be easily disassembled. Suppliers, contractors, engineering companies and the client need to focus on simple products but also CoPS to have a design to disassembly. It will lead towards different challenges knowing that the life span of products can vary from 5 to 100 years, (Arnoldussen et al., 2017).

Political:

These factors influence the business in the whole industry. Regulations and legislations can stimulate or prevent the development and implementation of products. Politics can also create policies to pressure companies in a certain way.

- ***Government***
  The budget of the government is shrinking but they are trying to limit the bureaucracy to cope with it, (Bouwend Nederland, 2012).

- ***European Union***
  The economic- and financial integration of the EU will continue. Furthermore tenders executed by the EU will increase and the EU will increase the regulation and legislation on i.e. air quality, noise and habitat, (Bouwend Nederland, 2012).

- ***Transparency***
  The government will set up regulations to increase transparency also after calls from the consumers to do so, (Bouwend Nederland, 2012).

- ***Mobility***
  Increasing demand for mobility is asking for innovation in infrastructural investments, (Rabobank Cijfers & Trends: Aannemersbedrijven grond-, water- en wegenbouw, n.d.).

Some other important changes that can be described which are more related on an organizational level including the tender are:

Public-private collaborations

- Due to the increase of public-private collaborations the chain is shifting. Companies are working together more often during the design- and planning phase (forward integration), and maintenance- and management phase (backward integration), (Pianoo: Marktbeschrijving GWW, n.d.).

Tenders

- More focus on quality instead of price within tenders.
- The focus on the Total Cost of Ownership (TCO) in tenders increases. It describes the total costs of a product during its technical life span.
- Pre-competitive stage is often used where there is room for experimentation. Companies can work together and learn from each other before a tender, (Arnoldussen et al., 2017).
- The traditional contracts are changing, the gap between design and implementation decreases. More integrated contracts are applied such as Design and Build/Construct, variations of Design-Build-Finance-Maintain-Operate, Best Value Procurement, and (sometimes) an open budget (with profit sharing), (Rabobank Cijfers & Trends: Aannemersbedrijven grond-, water- en wegenbouw, n.d.); (Pianoo: Marktbeschrijving GWW, n.d.).
- An increase in the use of MEAT-criteria is seen and is expected to increase some more, (Pianoo: Marktbeschrijving GWW, n.d.). The client wants to favour added value of innovation especially related to sustainability and risk management. You can think of the CO2-footprint, applying used materials, the amount of transport movements, and so on. Nevertheless companies say that there is still a high focus on price in relation to qualitative advantageous, (Rabobank Cijfers & Trends: Aannemersbedrijven grond-, water- en wegenbouw, n.d.).
- The client is moving the risks towards the contractor especially due to the new tendering forms. It requires knowledge on legal contract formation and risk management, (Rabobank Cijfers & Trends: Aannemersbedrijven grond-, water- en wegenbouw, n.d.).

Competition

- Companies are increasing their business from a supplier to a full-service provider. Besides providing a product they also carry out the implementation and the maintenance, (Bouwend Nederland, 2012).
- The time of forward- and backward integration of medium- and large-sized contractors seems over. Core values are evaluated and parts of the company are

sold. Collaboration with sub-contractors is increasing, (Rabobank Cijfers & Trends: Aannemersbedrijven grond-, water- en wegenbouw, n.d.).

4.4 Road construction sector and product innovations

The construction industry can be described as an industry which is one of the most regulated industries and one of the least innovative industries in the Netherlands. Especially the road construction industry is a project-based industry where each project is unique. The projects are often very complex and have products related to other products and systems, so called CoPS. Products that are developed have an architectural structure, related to different products and components, which can vary between projects. Wolbers (2012) described that the success of an innovation and its performance also depends on the decisions organizations make. He described the decisions to be divided into an organizational, operational, product and/or marketing decision. Wolbers (2012) also concluded that there is a lack of research about the dynamics of decision-making in relationship to innovations. The innovation-decision process is therefore important for the success of an innovation but lacks scientific research looking at the relationship between different variables within this process. Coenen (2017) looked at the innovation policy of the Dutch construction industry in relationship to other European countries knowing the United Kingdom, Denmark, Sweden and Germany who are considered as innovative leaders in Europe. An innovation policy was described as a public intervention to support the generation and diffusion of new products, processes or services. The research was focused on the comparisons and gaps between innovation policy and what lessons could be learned between the countries. Coenen (2017) described that the Dutch construction industry still has a weak trust level between organizations. The Netherlands has a strong policy towards financial incentives related to the development of innovations but on the contrary there is still a lack of collaboration between companies compared to the aforementioned countries. This could mean that there is a lack of information sharing and therefore knowledge of new innovations within the industry. The collaboration between the companies in the construction industry is partially being solved by the Bouwcampus which is a neutral place where contractors, clients, and knowledge institutions can collaborate in different ways to work together and create innovative solutions. The access to expertise is sufficient with different institutions and organizations such as PIANOo and the Ondernemersplein who offer, discuss and advice towards different procurement and construction related topics. Coenen (2017) also stated that the policy mix does not support the whole innovation trajectory on a specific level such as the road construction industry. The coordination of the policies is a point of interest where a lot of policies are standing alone. Overarching strategies such as the public procurement of innovation on a specific industry level could help to coordinate these policies for the whole innovation process including diffusion, adoption and upscaling. Political pressure could be used as a strategy to increase the upscaling of certain product innovations.
Looking at the skills and competences in the industry the market especially created initiatives themselves for training and education such as the BuildUpSkills network which was only supported by the government but not initiated. There are opportunities for the market to support knowledge sharing and -creation of new product innovations or its technology so that companies acquire the skills and competences to implement the innovation if necessary.
The most significant gap Coenen (2017) described was the relationship between standardization and the demand for innovation. The safety and security of the road networks have to be guaranteed via standardization which are mostly captured in legislations and regulations. But to apply new innovations the demand for several solutions should be clear whereas the current policy leaves big question marks for certain innovations on a product level if, where and when they can be implemented.
The ambitions of the Dutch construction industry were described by Bouwend Nederland (2012), which is a society for construction- and infrastructural companies, they summarized the current situation and the ambition for 2020, see table 4.

Past and current situation	Future – Ambition 2020
Positive – Proud of	**Positive - Dreams**
• Qualitative product • Flexibility • Collaboration in projects • Resilience during recession • Culture/motivation of hard working • Innovation and renewal in the sector • Craftsmanship • Broad social position of the construction industry	• Improved branch marketing • Improved inflow of personnel (quantity and quality) • Construction only needs assembly • Modernising business model • From contractor to supplier, more Product-Market-Combinations • Professionalized commissioning and other types of contracts (e.g. DBFM) • Innovation, from price to knowledge • Increased automation of the construction industry
Negative – Disappointed	**Negative – Nightmares**
• Vicious circle (from flexibility to costs for additional work) • Claim culture • Constructors are followers, limited capacity to think differently and to innovate • Bad image • Slow adoption time • High amount of time for projects • Low profits • Traditional client-supplier relationship	• Insecure what the government's policy will be • Deficit of personnel inflow (quantity and quality) • International companies that enter the market • Legalization (certifying, regulation, legislation) and a claim culture • Few open minded people • Price war, continued pressure on profits

Table 4. Summary of the current situation and the ambition of the construction industry in 2020.

In general it means that the industry feels proud of qualitative products and innovation within the industry and the collaboration with partners and even competitors. Contractors are disappointed about the risks and the claim culture that exist and describe contractors in general as followers with limited capacity to think differently and to innovate. The adoption time is described as very slow and each project consumes a lot of their time. In 2020 they hope for more automation within the sector, sufficient qualified personnel and a shift from price-oriented solutions towards more quality-oriented solutions. The government's future policy is described as insecure which makes the market a bit conservative. Together with an increase of regulations and legalizations it will de-motivate contractors to develop and/or implement new innovations in future projects. The sector also fears an industry with few open minded people and a price war that continues to pressure on the profits. All negative influences towards innovations within the Dutch construction industry.

The first issue that arises within the sector when looking at the innovation-decision process is a tendency and increase in deficit qualified personnel, a lack of competences, few open minded people to innovate and a slow adoption rate. These may influence the upscaling of product innovations since companies have a lack of knowledge, willingness to learn and so

to adopt and implement. The uncertainty about the government's policy in the future leaves them with a lack of knowledge about which innovations may be applied in future projects. Key decision-makers could therefore be informed in the knowledge stage, have a positive attitude but may decide not to adopt and implement an innovation due to these uncertainties. Coenen (2017) also described that policy makers are stimulating innovations enough in the TRL 1 to 8 via financial stimulants but lack a consistent strategy and clear future prospects for innovations to be applied in future projects and so to scale up. This uncoordinated policy leaves firms in an early stage to question the willingness to adopt since they are unsure if innovations could eventually be applied in several projects. Although a demand for certain characteristics of products in general are communicated, such as sustainable and circularity, it is still unclear in which projects it will be possible to apply and if it will be financially beneficial.

Antecedents of innovation in the construction industry

The government is the most important first user and buyer for most of the contractors and suppliers of product innovations. They are also the owner and system builder in the road construction industry and can therefore create a market for product innovations to be implemented. Caerteling et al. (2008) described that they affect technology commercialization of suppliers often through technology programs and standards. But it takes a lot of time before technologies or innovations are adopted and embedded as a dominant design. The government has a job to provide a qualitative and secure road infrastructure which is often achieved by formulating regulations and legislations, (Jacobsson and Bergek, 2004). These legislations and regulations are seen to be a great barrier for the road construction companies to measure the market potential of product innovations in future projects and therefore the willingness to adopt and scale up a product innovation. Arnoldussen et al. (2017) described the following barriers for innovations in the construction industry:

1. ***The government's policy is not really challenging and consistent***: the sector stated that the policy is not stimulating the innovation climate.
2. ***Rigidity in the application of legislations and regulations:*** which thwarted customization and gives few space for innovative entrepreneurship. For example the spatial policy which contributes to scarcity frustrates customer-oriented and innovative ways of working.
3. ***Restrictive aspects of the tender***: they only stimulate innovations when the request offers space for innovations and they are rewarded.
4. Benefits of an innovation are ***hard to internationalize*** for large renewal projects with a more fundamental character.
5. ***Lack of reputation mechanisms***: when an innovative reputation isn't awarded in the market, for example due to a lack of transparency or restrictions in tenders, it stops investments in innovations. These investments are not only necessary for companies who developed an innovation but also for the companies who want to apply an innovation from the supplier and are investing resources in order to do so.
6. ***Restricted upscaling possibilities***: a lot of small, especially unique, construction projects lead to a lack of upscaling possibilities for innovations and reduce the willingness of external parties to invest in the construction industry. Especially in the road construction industry there is a great difference between the small projects of municipalities and the large projects of RWS.
7. ***Risk avoiding behaviour:*** due to a combination of cost-orientation and often uncertainty about the performance of an innovation there is a tendency to choose current well-known solutions.
8. ***Lack of chain collaboration***: for large tenders medium- and large-sized contractors often work together in consortia. The company they are working with in one project is often a competitor in the next one. Current interests obstruct innovations to be

applied where companies protect their know-how and information about innovations towards their competitors.

9. ***Limit amount of knowledge creation and -sharing***: when systematic building of knowledge in subsequent projects is not a clear strategy it can have a negative effect on the diffusion of innovations and can decrease the adoption rate.

When taking into account the current situation, the trends and the status quo of innovations in the road construction industry they all influence the antecedents described in chapter 3.5 which are related to the upscaling of product innovations. An overview of how the road construction industry influences these antecedents in a positive (stimulant) or negative (barrier) way are formulated in appendix B.

4.5 Conclusion

When a product innovation is applied successfully for the first time and has some added value for the users of it the question rises in what way the road construction industry influences the upscaling of it. To scale up a product innovation the most important aspects are the demand for it and the possibility to apply it in future road construction projects. As described the characteristics of an innovation to scale up are i.e. that it needs to be embedded as a dominant design by the client(s) and contractor(s), and that it meet consumers' demand for a broad range of projects. Looking at the road construction industry the government's policy is not really challenging and consistent for contractors to apply innovations. The demand and thus upscaling potential between different clients such as RWS, provinces and municipalities is unclear and leaves contractors with uncertainties on when and where innovations can be applied in the future. Especially municipalities who use RAW contracts prescribe technical specifications which most of the time give little to no space to apply a (proven) product innovation. The restrictive aspects of the tender and the rigidity in the application of legislations and regulations demotivate contractors to invest in the development and/or adoption of new product innovations. It results in a lack of diffusion, adoption and upscaling of product innovations.
The government as a sponsor of innovations for TRL1-8 is sufficient but as a regulator they often prevent upscaling to occur. Due to a lack of chain collaboration, trust within the sector and limited amount of knowledge creation- and sharing it can be difficult for contractors but also for the client(s) to adopt and implement a product innovation in their working processes. The innovation-decision process often stops at the knowledge or persuasion stage since there is no or less willingness to pursuit activities that lead towards the implementation of the innovation when it is not always clear it can be applied in future projects. A business model with unclear market potential is one of the largest barriers for scaling up a product innovation. Looking at the current situation and the trends of the road construction industry companies are becoming more and more specialized. Knowledge assimilation is therefore very important within the market which could stimulate contractors to be informed and able to cope with new product innovations in a faster pace. Ageing and degeneration are and will be an even bigger issue in the future for contractors which makes them less able to cope with innovations and it decreases their innovative power. On the other hand new technologies can increase the learning capability of companies and employees but will also ask contractors to invest a lot of their resources.
For large contracts of RWS there is a limited amount of competition. Together with questionable economic prospects, the large size of tenders, the high costs, and the related risks it makes contractors less willing to implement innovations. Contractors are not really stimulated or rewarded when they implement innovations. Nevertheless integrated contracts give more opportunities for innovations to be applied together with an increase of stimulant MEAT-criteria. Finally availability of a technology could increase the diffusion of innovations and create a level playing field within the sector when several similar products are developed. Standardization is therefore increasing which could lead towards product

innovations to be embedded as a dominant design but on the contrary will decrease the potential for new product innovations to be implemented and so to scale up.

Chapter 5. Contractors and product innovations in the road construction sector

5.1 Introduction

The success of scaling op proven product innovations lies towards RWS but also the willingness and ability of contractors to adopt and apply a product innovation in tenders. There is a great difference between product innovations supplied by a third party, by the contractor themselves or developed with RWS as a stimulator. Nevertheless for product innovations to be scaled up contractors and key decision-makers within those companies are important to take into account when they do or don't apply a product innovation. On the other hand RWS as the client should ask for product innovations (in)directly, give space and/or even stimulate the implementation of certain types of product innovations. Whereas for provinces and municipalities the amount of road construction companies are quite large the amount of contractors that are able to compete in large construction projects of RWS is small. There are only 10 large contractors and some medium-sized contractors who work together with large contractors in a consortium in order to compete. To get an understanding how these contractors make a decision whether or not to apply a product innovation and why product innovations are or aren't scaled up interviews are held with key persons of 10 contractors who are related to innovations. In the next paragraphs the focus lies towards the outcomes of these interviews focusing on the influential factors to scale up product innovations and specifically more towards the stimulants and barriers. First the outline of the interviews, the data gathering process and how the data is coded and validated are described.

5.2 Interviews and data collection

To collect the qualitative data from the contractors interviews were held. In order to create a better understanding about the value of the data the goal of the interviews is described, the questionnaire which was used, the selection process of the contractors and the coding and validation process of the data.

Goal:
The goal of the interviews was to create an understanding on the important factors influencing the upscaling process of product innovations at contractors for large construction projects of RWS. Questions mainly focused on when does a contractor diffuse, adopt and apply an innovation, what types of innovations, and what are important barriers and stimulants for scaling up product innovations. It was especially focused on large construction projects of RWS which is needed to get an understanding where RWS could influence the upscaling process of product innovations.

Questionnaire:
With the current theoretical framework in chapter 3 focusing on the upscaling of product innovations a questionnaire with open questions was formulated. To get an answer on the sub-question 5 "how are contractors influenced to apply product innovations in tenders of RWS" the focus in this research lies at the adoption and diffusion process of Rogers (2003) looking at the characteristics of the innovation, the communication channels used, the time and the social system. Furthermore the innovation strategy of companies was asked specifically to see where different organizations are focusing on and to see if and how it is related to RWS. The innovation strategy is also an important organizational factor which could influence the adoption, implementation and upscaling of product innovations. Finally barriers and stimulants to scale up product innovations are asked to get a better

understanding on where RWS should focus on. Some questions and answers were deleted since they had no relevance or value for the research. It resulted in the following questionnaire, see appendix C – Questionnaire.

Selection process contractors:
By analysing different organizations and checking for differences in the size of the companies it should be taken into account that biases can occur. The validity of the outcomes are registered at one point in time and from one person of each contractor. This will be taken into account when coding and validating the results. It is difficult to know how many employees are really active for only the road construction industry especially focusing on large contracts of RWS. Together with experts of RWS, who are related to the road construction companies and stimulating innovations in projects, the companies and the interviewed persons of contractors were chosen. This method is the so called purposive (judgemental) sampling, meaning a type of nonprobability sampling in which the units to be observed are selected on the basis of researcher's judgment about which ones will be the most useful or representative (Babbie, p.193). The list with the contractors, the indicated amount of employees of the whole organization, the interviewed persons and their functions are described in appendix D – Companies and interviewed persons.

Coding and validation
All interviews were recorded with permission of the interviewees, one person filled in the questionnaire digitally due to a lack of time, see appendix E2 – Ooms Civiel. The interview with Volker Wessels, see appendix E8, was excluded since it became clear during the interview that KWS Infra is the executive company for the GWW for Volker Wessels and the managing director believed in a strongly decentralized structure where all daughter companies should run most activities on their own without steering from a corporate level towards i.e. innovations. Therefore only the data of KWS is used since an overlap of these two could influence the outcome of the data were only 10 contractors were interviewed.
All information was formulated carefully and described at each point of the questionnaire as good as possible, see all outcomes in appendix E. The first conclusion to be drawn from the outcomes is that it was difficult to get a clear understanding about the adoption and diffusion process of product innovations in general. For example the most important characteristics and communication channels differ between products, persons but also organizations. Another point of attention was the fact that most contractors only developed innovations themselves or with partners and didn’t bought (most of their) innovations or diffuse their own innovations towards other competitors. Furthermore only one person was asked for each organization where communication channels and the innovation decision-making process are especially focused on face-to-face meetings of several involved employees. The data made it unable to generalize the diffusion process for product innovations since each has its own advantages, complexity, regulations they need to comply to et cetera especially due to the unique project-based tenders. Therefore the most important findings are summed up for the diffusion process as to get an understanding on what possible ways contractors use which could then be used in further research to check which were specifically important for different product innovations in different tenders and how these differ over time looking at the innovation-decision process of several individuals. Also the members of a social system within a company have to be analysed more thoroughly to see how they influence each other and how it influences the innovation-decision process and the upscaling of product innovations. Coding was used for the gathered data to combine different stimulants and barriers related to the described antecedents from the theoretical framework. Coding was also used to remove double answers and to make the answers readable. The theoretical framework of antecedents, stimulants and barriers, will therefore be used as a guideline where new barriers and stimulants could be added.

5.3 Diffusion and adoption of product innovations

During the interviews it was clear that due to the different types of innovations the diffusion process was not one-sided and it was impossible to describe a general diffusion process for product innovations. It resulted in a lack of information in some interviews where further research should focus on the diffusion process of specific types of product innovations in different tenders. The decision was made to describe the main findings whereas it is mostly giving an indication about the different possibilities and choices contractors in general could make. When looking at the diffusion process 4 main factors play a role, the innovation, communication channels, time and the members of a social system. First the product innovations described by the contractors that were or weren't scaled up are summarized:

Scaled up:

- Asphalt (mixtures).
- ZOAB (developed by Heijmans, bought by RWS and expanded by RWS in the market).
- Recycled ZOAB (re-generated ZOAB).
- AIR ZOAB (50% recycling).
- Sealoflex modified bitumen (since the 80s).
- Silent road – still developing (RWS initiative).
- Road Energy Systems (since the 90s).
- OPA8 (3rd generation ZOAB).

Not scaled up:

- Road of the future, LED-lightning and solar panels (successful implemented, but isn't used in other projects).
- A solution to drill a small hole in the road to be able to see how long the road will last (were the only supplier which RWS didn't wanted).
- Way in Motion, didn't scale up because RWS doesn't have a clear view what to do with it and how to connect all the information (data).
- Self-cleaning bank, often not applied due to specifications.
- Jointless connection between the road and a bridge.
- "Zonneweg", is one of the innovations which wasn't applied in other projects without a clear reason.
- ML-TRAC.
- Warm Mix Asphalt using waxes.

Looking at the product innovations that are scaled up the contractors specifically named types of asphalt. It is one of the products in a road construction project with the most physical impact and highest costs. It is also one of the products RWS takes the lead towards the development of certain types such as recycled asphalt or noise reducing asphalt. A bias in the data can be described towards the internal validity. Since most of the interviewed companies are large contractors with their own asphalt plant where they develop, produce and implement these products. Other companies could potentially develop product innovations which are implemented by the contractors but are not mentioned. Other types of product innovations were developed by the contractors themselves which didn't scale up due to several reasons. Further research should therefore look at innovations applied by suppliers other than contractors to see if they are implemented in several projects and are therefore successfully scaled up or not.
When looking at the diffusion of product innovations some general findings can be described. First the characteristics of the innovation were summed up:

Characteristics of a product innovation
In the diffusion process knowledge of the product innovation is communicated through different channels over time among members of the social system. Since the characteristics as described by Rogers (2003) are different for each innovation it is hard to get a clear understanding on which are the most important in their decision to adopt and implement the innovation. The characteristics as earlier described were the relative advantage, complexity, compatibility, observability and trialability. Nevertheless it gives an indication on where contractors are focusing on. The relative advantages that were mentioned in the interviews are:
- Sustainability
- Energy usage
- Low amount of carbon dioxide
- Recyclable
- Cost advantage
- Advantage compared to the MEAT-criteria, especially if it is more expensive than the product it replaces.
- Lifecycle cost (LCC)
- Total cost of ownership (TCO)
- Time-effective
- Risk level

Looking at the complexity contractors often prefer that it stays close to their core business. Especially for SME's like Van Wijk who have less resources and capabilities. Nevertheless contractors are willing to learn new skills and competences but it mostly depends on the investment that have to be made and the consequences and risks which are involved. Most innovations though are incremental innovations and based upon existing skills and competences.

The compatibility can be important but often more complex innovations are custom-made such as traffic management system. If a product is successfully applied in a contract it should get a client satisfaction declaration which could make a product called proven. Nevertheless it can be important depending upon the project and if it is part of a CoPS. Also legislations and regulations could still prevent an innovation to be applied again in other projects.

The observability is not described as a high concern. It depends on the characteristics of the product innovations and the persons involved if it is an important issue. Since companies don't want to bear any risks it is important that companies are able to look at the benefits before they adopt and implement the product innovation. Public and political support can be an important factor in the observability to increase the willingness for contractors to adopt and apply product innovations.

Finally the trialability of a product innovation is important for a contractor if it is not yet tested or validated. If it is tested it is of less importance. For product innovations which are relatively new, the certainty of the outcomes isn't always clear so it can still be important over time before it is of less importance. Some contractors also want to apply it first in their own projects before they want to apply it in all of their projects.

Communication channels:
The communication channels as described earlier can be defined as the process by which participants create and share information with each another in order to reach a mutual understanding, (Rogers, 2003, p.18). For an innovation it is essential that information is exchanged towards one or more individuals which is needed in the knowledge stage of the innovation-decision process. Then decision-makers can create an attitude an start activities

in their company and with partners in order to cope with the innovation and make a decision whether to adopt and implement the innovation.

Looking at the communication channels of the contractors, most of them have an internal source to share information about innovations, have an innovation day and share information about innovations in meetings. Some of the channels that were mentioned to acquire or share information are: professional journals, linked-in groups, fairs, “Knowledge Centre Asphalt”, Bouwend Nederland, MKB Infra, Infra Innovation Network, WOW (Wegbeheerders Ontmoeten Wegbeheerders) and Universities. There are many communication channels possible and a lot of different decision-makers which makes it difficult to find the “right” channels. Nevertheless as Rogers (2003) mentioned the interpersonal face-to-face communication is most effective and key decision-makers should be analysed to know in which innovations they are interested and how they acquire information via mass media channels in order to understand how innovations are successfully diffused, how many information was needed to receive in order to create a positive attitude of key decision-makers and what activities were needed internally and externally before an innovations was finally adopted and implemented.

Time:
Time in the diffusion process was described by Rogers (2003) as the number of members of the system who adopt the innovation in a given time period, (Rogers, 2003, p. 20). The time needed for the development of the innovation is also important for the adoption rate of an innovation. If relevant adopters are involved and informed during the whole innovation process it will be more likely they will adopt the innovation faster when it reaches TRL-9 and therefore upscaling would more likely occur. The characteristics of the decision-makers are hard to define whereas one individual is very slow in adopting an innovation and the other is actively seeking for innovations. Since there are large differences between different types of innovations and decision-makers especially the innovation-decision process should be analysed in further research in what stage of the innovation-decision process different decision-makers were involved and how long each step in the innovation-decision process took before the product was adopted and implemented. Contractors mentioned that asphalt could sometimes be developed within one year whereas for example the SolaRoad which integrates solar cells into the road started developing in 2010 and is still in the developing stage. It gives companies who are willing to adopt and implement the product more time to acquire information, see test results, adjust their working processes et cetera. During the innovation-decision process the stimulants and barriers should be taken into account whether they influence the adoption rate and if there is a certain amount of adopters in a social system that created a momentum leading to the implementation and upscaling of a product innovation.

Social System:
A social system was described by Rogers (2003) as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. This could be several companies within the market or several members within an organization. Variables such as the common goal or the type of product innovations differ which influences the social system. If the product innovation is part of CoPS it is more likely that several organizations and multiple decision-makers within each company are involved which makes the adoption rate harder before it could eventually be implemented. An innovation could be developed due to a goal set up by RWS, for example to reduce noise, or could be developed related to organizational goals such as cost reduction, sustainability or profit.
Looking at the contractors a common sound is heard that the management often makes the decision whether or not to develop, adopt and/or implement a product innovation. Different employees with different roles are often involved which can prevent an innovation to be adopted and implemented by the contractors, their partners and/or RWS. Some examples are innovation managers, contract managers, project managers, technicians, procurement

employees and so on. Therefore it is important that the client clearly defines and discusses the goals with the market and involves the relevant members of the social system for different types of goals and related product innovations.
The formal and informal structures of the social system could be integrated in for example the Bouwcampus or CROW where overarching goals of RWS can be discussed with the relevant members of the social system after the management has agreed on a broad vision and the goals that needs to be taken. Companies also have their own partners and goals which could make them decide not to adopt and implement an innovation. However as discussed earlier only few studies did research on how social structure or communication affects the diffusion and adoption of innovation in a system which should be a point of interest in further research.

Innovation strategy:
Looking at the contractors most of them focus on process innovations rather than on product innovations. They often don't have a clear innovation strategy whereas it is often unclear if they will be able to apply a product innovation in future projects. The market potential and therefore the return on investment and profit are not always clear and RWS also changes their demands and wishes from time to time. Therefore they tend to follow RWS who steers towards some developments. For example asphalt where a lot of developments and innovations occur, most contractors say they only have the benefit of one or two projects before another contractor develops some similar product. Therefore the market is very conservative in telling their innovations (and ideas) because competitors often try to copy it. Nevertheless it does stimulate contractors to develop product innovations since they don't want to lose their competitive advantage or stay behind. The focus still lies towards asphalt which especially for small- and medium sized companies is an issue where they don't have their own plant to develop and produce it. The large contractors often develop innovations themselves or together with partners and don't sell them towards competitors. Some contractors such as Heijmans and BAM did though but in the construction industry it is not very common. Some contractors also stated that if they do develop a product innovation they want to earn it back within one project whereas Heijmans for example has their own innovation strategy and are less focused on earning it back within one project. The reason could be as mentioned that they are afraid it will be copied within a limited amount of time and that it is often unsure if they can apply it in other projects. Therefore it is less likely for most large contractors that radical innovations are developed and implemented. They often stay close towards their core competences when developing and implementing a product innovation and focus on what RWS explicitly asks. It results in incremental innovations which are often not diffused and adopted by other contractors since it wasn't sold. Innovations are then only embedded as a dominant design by one contractor which means it can only scale up if that one contractor wins all tenders or standardization by RWS is applied in tenders.

5.4 Stimulants and barriers to scale up product innovations

The stimulants and barriers described by the contractors in the interviews were coded to make them readable and to relate them to the different antecedents formulated in the conclusion of the theoretical framework in chapter 3 for scaling up product innovations. In appendix F an overview of the theoretical framework with the antecedents was formulated plus the barriers and stimulants described by the contractors. Also a "yes" described if the theory in chapter 3 described a stimulant (st) and/or barrier (ba) to see which stimulants and barriers were and weren't described by the contractors. The barriers and stimulants described by the contractors were coded and formulated into the table to get an overview of the factors influencing the adoption, implementation and upscaling of product innovations.

Looking at the barriers and stimulants described by the interviewed contractors especially the individual and innovation level weren't described much. First of all the innovation level is too

specific whereas every product is different in their own relative advantage, complexity et cetera so it is hard to clearly state important barriers or stimulants related to all. Also these characteristics are partially answered in the questionnaire making them of less relevance. The individual level is described in some interviews but when focusing on the innovation-decision process the organizational and environmental characteristics will often determine if the management will adopt and implement a product innovation. Furthermore only one person of each company was interviewed which makes it difficult to describe barriers and stimulants on an individual level which relates to more product innovations and projects. The environmental and organizational level antecedents, barriers and stimulants, are mostly related to RWS and/or can be influenced by them so these answers are more valuable. Therefore these will be taken into account to see what are the most important outcomes whereas in further research the innovation and individual level stimulants and barriers in the innovation-decision processes could be analysed into more detail for a specific product innovation in different projects and members of the social system.

First of all it still have to be taken into account that 9 contractors were asked via open questions what they find important barriers and stimulants for scaling up product innovations. Some conclusions can be drawn from it whereas some factors are described more often than others. Nevertheless it could very well be that a stimulant described by only one contractor could also be a stimulant for another contractor but at the moment of the interview wasn't mentioned. Time could also play a role whereas opinions, environmental factors, and organizational factors can differ over time. Still some barriers and stimulants were described more often than others which could be an indication that they are indeed more important than others. On the environmental level the most described **barriers** and **stimulants** were:

- Regulations and legislations
- Requirements and wishes (demand)
- Coordination and integration of companies in the market

The ***regulations and legislations*** are formulated as a stimulant as well as a barrier. Contractors mentioned that they often can't implement a product innovation again in RWS projects due to reference requirements of a product where they have to comply to. Regulations and legislations are often not adjusted in future projects which also de-motivates contractors to develop, adopt and/or implement product innovations (again). Also relatively new product innovations have to be proven for a longer period of time which is not always the case which could prevent upscaling to occur. If agreements weren't made in advance in the trace/request of the tender it could give space and stimulate contractors to apply product innovations. Flexible contracts which could be adjusted more easily when requested would also stimulate product innovations to be adopted and implemented in order for them to scale up.

The ***requirements and wishes (demand)*** were also mentioned more often as a barrier and as a stimulant. Especially as a barrier since it is often not clear what market potential and certainty a product innovation has and if it can be applied in future projects. Also RWS was described as not reliable whereas they change their requirements and wishes from time to time leaving contractors uncertain about the return on investment of product innovations. On the other hand several stimulants were described opposite to these barriers. If RWS is clear about innovations, that are tested and/or applied for the first time, when and where in future projects they could be applied it will stimulate the adoption and implementation of product innovations. A clear roadmap is requested whereas for example the road of the future N329 in Oss needs such roadmap for products to describe where they could be applied after tests are successful. Clear goals and demands should also be formulated more on an outcome-based level such as the desired life time or the % of recycled material in new product innovations. If RWS describes that they want an energy-neutral road it could stimulate product innovations to be applied if it is clear what they expect from contractors. It should be discussed within the market if it is realistic, and how and when certain goals can be

achieved. RWS could also ask for innovations directly especially on the long term stimulating innovations to be implemented. Finally a clear vision and goals should be formulated together with provinces and municipalities whereas RWS is only a small part of the total road construction industry and there is a lot of overlap between product innovations that can be applied. But there is no clear overarching strategy defining which product innovations with which added value are requested and when and where they could be applied. Therefore product innovations in RWS projects are often only developed by RWS initiatives which gives them more certainty that it may be applied in future projects.

Coordination and integration of companies in the market was also described as a barrier and a stimulant. There is little coordination between product innovations which are applied at RWS which could also be applied by municipalities and provinces and vice versa. Clear coordination between these clients can increase the market- and upscaling potential of product innovations. It would increase the willingness of contractors to diffuse, adopt and implement product innovations.
Internally RWS expresses their wishes towards e.g. sustainability but the procurement department doesn't clearly describe these ambitions in a lot of project tenders which was seen as a barrier for the implementation and upscaling of product innovations. Added value from a product innovation towards sustainability is then not always rewarded which could de-motivate contractors to buy/develop product innovations. To stimulate product innovations RWS could facilitate areas for open innovation and push contractors to develop certain types of product innovation. RWS should let the market buy products from each other and accept that one contractor innovates more or is the only supplier, in essence it is how a healthy market normally works.
A program set up by RWS could stimulate innovations being developed, applied and implemented. The program should clearly describe what RWS wants and what the goals of the program are. RWS can take the lead in the development of certain topics related to product(groups) or CoPS, where the market can also learn from each other and share knowledge. A neutral party could stimulate product innovations to be applied such as CROW where it can take a facilitating role in for example sustainable products and the knowledge creation and dissemination. Finally as already mentioned the market opportunities for product innovations are very different between tenders of RWS, provinces and municipalities. It would stimulate product innovations to be scaled up when RWS collaborates more with provinces and municipalities to set up clear goals on what product innovations should be developed and communicate in which future projects of which client it could be applied especially since there is often an overlap between the roads of these clients. The IPO (Integraal Provinciaal Overleg) could be one of the channels that can be used in order to do so.

The most described **barriers** and **stimulants** on the organizational level were:

- The contract (size, duration, specification and award criteria)
- Communication with the procuring body
- Communication about the innovation
- The procurement process

The ***contract*** or ***tender*** is the most described stimulants as well as barrier mentioned by the contractors to scale up product innovations. It is related to clear requirements and wishes but also the regulations and legislations. Barriers that were described are that the fictive price discounts are in no relationship with the costs for an innovation in a project so it doesn't stimulate the adoption and implementation of it. Looking more into the MEAT-criteria (Most Economic Advantageous Tender) it often doesn't result in distinctive outcomes between contractors because the percentage of the MEAT on the total tender price is too low or the outcomes are rated moderately with a 7 or an 8. Also some criteria such as the CO2-ladder level 5 and the "vehicle lost hours" can be achieved by almost every contractor which doesn't make them distinctive and doesn't stimulate product innovations to be applied. Another point

mentioned from the interviews as a barrier is that there is no appreciation in tenders for innovative companies. The focus on price instead of quality still occurs which makes it necessary for a product innovation to have a higher quality and have lower costs than the product it replaces. Due to legislations and regulations often technical requirements are still described preventing product innovations to be applied again.
On the contrary MEAT is described by almost every contractor as an important stimulant to apply and scale up product innovations. It should give a significant reward related to the standards that are currently used. The criteria in tenders that are described should lead to distinctive outcomes to make it a stimulant. The way MEAT is measured should be clear for contractors whereas Dubocalc was a good initiative but there are cases where contractors who “write” sustainability better receive higher scores. Standards should be described in order to make it clear for contractors what they could earn. Functional specifications can also stimulate product innovations to be applied again which gives space for contractors to apply innovations. DBFM-contracts are often more flexible and functionally described whereas D&C- and RAW-contracts are less flexible and have more prescribed technical requirements. RWS could also ask directly for innovations in a project or can require a percentage of the product that are applied to be patented in order to stimulate innovations to be applied.

The ***communication with the procuring body*** is especially described as an important barrier. Information about innovations are often not shared by the supplier or RWS. RWS is also reserved in making appointments with contractors since they are afraid that they are favouring a company which is forbidden. Contractors also mention that it is hard to find the right persons at RWS to apply innovations. Also after the technology was finally discussed it is hard to convince contract managers, project managers, et cetera to integrate it in their working processes and tenders. Especially for new (radical) innovations it is often unclear who to talk to.

When looking more into the ***communication about the innovation*** a barrier which was described is that RWS keeps information from contractors such as developments they do with TNO. Also a lack of communication occurs between RWS, contractors and/or suppliers of a product innovation to discuss and to solve problems related to the innovation. Finally RWS was described as very slow in their communication towards new developments and innovations which could even take years in some cases. A stimulant which was described which could benefit product innovations to be applied and eventually scaled up is when RWS discusses more with the market about innovations, the risks, regulations and legislations. Then it can be discussed how it could be adjusted or managed in future projects in order for the innovation to be applied and scaled up.

Finally the ***procurement process*** was described mostly as a barrier to apply innovations. Often there is little time between the application and the tender itself and adjustments within this period are not made very often by RWS. Therefore contractors often rely on existing and well-known technologies. RWS sometimes uses a market consultation or dialogue session with contractors but it makes it difficult for contractors to put their ideas and innovations on the table since competitors will then know it too. As discussed it is often unclear how MEAT-criteria are measured which makes it hard for contractors to compare themselves and the related product innovations with each other. Finally a contractor mentioned that the contracting department of RWS isn’t involved enough during the development and testing stages of product innovations. Sometimes RWS held a contest and an innovation was chosen but it couldn’t be applied in projects since the contracting department was involved too late.

Besides these mentioned points the high tendering costs were also a barrier especially for large contracts, where MEAT-criteria often doesn’t lead to distinctive outcomes between contractors. High risks and fines are an important barrier for contractors to apply product innovations which increases the use of traditional well known products.

5.5 Conclusion

Looking at product innovations that were applied and scaled up it were mostly different types of asphalt stimulated and directed by RWS. Other product innovations were mostly developed by themselves or with partners that didn't scale up. Contractors tend not to share information about their innovations and diffusion of their product innovations towards other contractors as well as buying from other contractors is not very common in the road construction industry.
The diffusion process could not clearly be defined which had little value towards how contractors are adopting and implementing innovations in general. Also for large construction projects of RWS it was seen that the large contractors often work together with each other and even with some medium-sized contractors to compete in tenders. They often hold their cards to their own and will apply well-known existing products instead of new product innovations. The lack of chain collaboration and trust could be influential. Looking at the described barriers and stimulants to scale up product innovations on an environmental level, regulations and legislations often prevent contractors to be able to apply product innovations (again) whereas RWS often doesn't change them in projects when requested. If they are made more flexible it could stimulate product innovations to be applied. More important are clear requirements and wishes described by RWS. Often RWS changes their demands and it is not clear if a product innovation, which is applied successfully in a project, could be applied again in other projects. Contractors are therefore de-motivated and unable to determine what the market potential of a product innovation really is and so what the return on investment and profit will be. Whereas RWS is one public procurer the provinces and municipalities have more rigid contracts but have a large share in the market potential for some product innovations. RWS should collaborate more with them. A roadmap describing where innovations could be tested and validated, where they can be applied for the first time and in which future tenders they may be applied could be helpful. On an organizational level the most important aspect is the tender itself. It often has technical specifications which are not adjusted for product innovations. Also the MEAT-criteria in many projects are in no relationship to the costs companies make for an innovation and are not making a distinctive outcome between competitors. The outcomes are often rated moderately for all applicants. RWS should describe clear wishes and requirements in future projects and what criteria they will ask to create market potential and stimulate the willingness for contractors to diffuse and adopt innovations. It should be stimulating in a way that it makes a difference in the total price of a tender and the way MEAT-criteria are measured should be formulated via several standards so contractors are willing to innovate and implement product innovations. The procurement department should be more involved in the innovation process of product innovations in order for product innovations to be implemented (or at least able to) in tenders. RWS should communicate more with contractors about innovations to manage risks and make space for innovations in future projects. At RWS communication can take a long time and it is not always clear who to talk to. A clear vision and smart goals formulated in programs could be a solution where members of the social system and especially contractors find each other, discuss innovations, share knowledge and implement innovations in tenders in order for the product innovation to be scaled up.

Chapter 6. Rijkswaterstaat and upscaling product innovations

6.1 Introduction RWS

RWS was founded somewhere between 1795 and 1813 during the Frans period. It started in 1798 as the “Bureau voor den Waterstaat” focusing on the construction, management and maintenance of rivers, canals, flood defences and polders. In the 19th century with the arrival of the train and car the tasks were expanded with the railway network, bridges and roads. In the beginning of the 20th century science influenced the daily work of RWS with new measuring techniques, improved materials (such as prestressed concrete) and it became possible to construct larger projects. After the war RWS was rebuilding the road network from 100 to 600 kilometre between 1945 to 1965. Also more attention came to widen and connect existing roads and to replace a lot of crossroads with tunnels, viaducts and fly-overs. Since the 60s the mobility in the Netherlands increased rapidly together with the welfare of the country. Safety and availability of the roads became more important and at the same time environmental regulations were increasing which resulted in policies towards the environment and nature. From the 1970s RWS starts to change their core business from an engineer and constructor towards the manager of the infrastructure. The market is then becoming responsible for the construction and RWS starts to work together with citizens during their planning- and decision-making processes. Nowadays a lot of societal challenges are demanding RWS and the market to change the way they work and the products they are using. Therefore the focus to develop and implement new product innovations increases. The amount of regulations, legislations, the different stakeholders and the project-based characteristics of the infrastructure with long lead times increases the complexity for innovations to be applied. It decreases the flexibility to implement innovations whereas the quality, safety, liveability and accessibility have to be secured. Especially in large projects of RWS the question rises how RWS can influence contractors to implement and scale up product innovations. The next paragraphs will describe some more information about the project-based organization, procurement and tenders, and the procurement and upscaling of product innovations by RWS.

6.2 The project-based organization

Rijkswaterstaat is the executive department of the ministry of Infrastructure and Environment in the Netherlands. With around 8700 employees they operate via 7 different national divisions and 7 regional divisions with a management board on top, see appendix G.
From the 7 national divisions GPO (Large Projects and Maintenance) and PPO (Program, Projects and Maintenance) are the departments responsible for the construction and maintenance of the national highways. This report focuses on GPO which has 4 main departments namely:

- Procurement- and tender management
- Production- and project management
- Engineering and technical management
- Business management and process control

From the 1970s RWS changed their business from being an engineering and construction company towards a more project-based management organization. Infrastructural projects are necessary for the mobility and economic growth in the Netherlands which has to deal with the topics such as the urbanization, digitalization and sustainability. The ministry of Infrastructure and Environment has written an overview of current and future projects and programs in the so called MIRT (in Dutch: Meerjarenprogramma Infrastructuur, Ruimte en Transport). The MIRT has intensive collaboration between provinces, municipalities, water authorities and transportation regions. The MIRT facilitates a management meeting every year with each of the 5 MIRT-areas (North, East, South, South-West, and North-West).

Nevertheless the MIRT only describes a broad policy such as sustainability, safety, mobility and so on, which is written in the Structure Vision Infrastructure and Environment (in Dutch: Structuurvisie Infrastructuur en Ruimte, SVIR). The MIRT has some more specific goals described whereas sustainability is now even an integrated part of the plan. The ambition to be energy- and climate neutral in 2030 is one of the most important aspects. The first energy-neutral road that will be realized is the project A6-Almere which is part of a larger program Schiphol-Amsterdam-Almere (SAA). Some national programs and some programs related to a specific region were set up and described in the MIRT related to the road construction industry:

- "More Safety", to reduce injuries and deaths as a result of accidents on the main road network.
- "Multi-year noise remediation program". For national highways the target was set to 60 decibel. Silent roads and noise barriers are some examples where RWS is focusing on which are being developed with the market.
- National Collaboration Program Air Quality.
- "Beter Benutten" where in the first phase the goal is to achieve 20% reduction of congestion during rush hours on specific corridors of the busiest areas in the country.
- Program Replacement and Renovation main roads.
- Program SmartwayZ.NL, to improve the business climate of Brainport South-East Netherlands and Greenport Venlo. Its goal is to increase the mobility system with smart techniques and innovations such as Intelligent Transportation Systems and Smart Mobility.
  One of the projects from SmartwayZ.NL is the InnovA58. With 160 kilometre of road at the A58 between Breda and Tilburg an additional task of the project was to investigate how innovations could contribute to solutions and how to pace it up.
- "Acceptation and chances for spatial integration of new energy systems". Focusing to pace up the energy transition towards a more sustainable one.

Looking at these programs they could be helpful to investigate and invest in possible solutions and to stimulate product innovations where possible. Nevertheless most of the programs don't have specific (smart) goals related to the potential added value of product innovations or a CoPS as a whole. It makes it difficult to know when and where certain types of product innovations could be applied in future projects. The requested improvements and outcomes on a product level are not clearly defined.
Employees of RWS also mentioned that some innovations are not applied anymore after they were successfully applied once. This could be the case for innovations that will be applied at InnovA58. Another testing location where innovations are applied is the so called "Road of the Future" in Oss, the N329. But a clear roadmap after the first successful implementation of a product innovation is missing.

When developing and implementing innovations it should be discussed within RWS to see if it can be applied in more projects which could then be communicated to the market. Gerling (2014) did a research on inter-project learning within projects of RWS. He described the characteristics, originally formulated by Gann and Salter (2000, p.959), of project-based firms in the construction industry:

- Projects create the core around which design- and production processes are organized.
- Mostly one-off productions or at least highly customised products and services.
- They operate in varying of companies along the supplier-customer chain.

Looking at the different projects, each project is managed by a team of RWS, the so called IPM-team (Integral Project Management). RWS appoints a Project Manager, Manager Project Control, Environmental Manager, Technical Manager and a Contract Manager to guide and control the realisation and exploitation phase of the project. On the basis of the contract the roles and responsibilities are communicated between RWS and the executive

party. Between projects Gerling (2014) also looked at inter-project learning and innovations within RWS projects. His conclusion was that inter-project learning on innovations had too little attention at projects of RWS. Furthermore he saw no control mechanism towards this process of learning between projects whereas learning was often done on a voluntary basis and via informal networks. The positive side of his research was that employees of RWS acknowledged the fact that innovation is important and that the learning process can and has to be improved in the future. The next paragraph will give some more insight information about how projects are originated and how the tendering process at RWS works.

6.3 Procurement and tenders

Each project has different stakeholders and environmental aspects to deal with. Different requirements, wishes and regulations for each tender are therefore inevitable. RWS needs to deal with unique and complex situations. The creation of road construction projects of RWS can be described into 8 different phases from the first initiative to the maintenance:

Phase 1: Initiative
The government and politics take the initiative and decide if an infrastructural project needs to be executed. RWS will act as the client towards the market. Future projects are often already described in the MIRT as discussed.

Phase 2: Exploring
The problem will be analysed and first thoughts about the solution will take place. Often they will call on the knowledge and experience of the market at this phase. In addition they will try to stimulate the market to come up with innovative and sustainable solutions.

Phase 3: Plan study
In this phase different alternatives are being investigated and proposed where public participation plays an important role. The minister takes a decision about the definitive solution in the so called track decision (in Dutch: tracébesluit).
Before the track decision had been made a draft track decision (in Dutch: ontwerp-tracébesluit) was formulated which is then discussed with related provinces, municipalities and water boards. The draft track decision holds several specifications such as:

- Infrastructural measures that have to be taken;
- Measures to compensate for damage to the nature;
- Measures related to the safety of the highways;
- Detailed maps;
- Number of lanes;
- Maximum amount of noise production.

In general the track decision that is made only includes spatial planning aspects such as the exact location, landscaping, height, dimensions and the connection to other roads. Then if no appeals were made permits could be acquired and finally the minister will execute an “evaluation test” (in Dutch: opleveringstoets). Then RWS will start the next phase to procure and execute the track decision.

Phase 4: Elaboration
In main lines the solution is known, RWS will then start to make a procurement plan and will formulate the tender, see appendix H. For projects above 2.225 million euro and especially projects above 65 million euro where the GPO department of RWS is focusing on they will need to comply to EU procurement guidelines and will be publicly tendered. Nevertheless there are still requirements to which companies need to comply to which especially for small-sized and some medium-sized companies

makes it often impossible to comply and so to compete, especially for large projects. The aspects that will be described by RWS in the procurement plan are:

- The purchasing need
    - Reason to procure
    - Description of the contract/project
    - Motivation and goals
    - Quality, results, and requirements to the product
    - Preconditions and starting points
    - Relationship with other relevant or related procurement trajectories
- Estimation
    - Estimation
    - Budget
    - Expenditure overview
- Risks
    - Inventory
    - Probability and impact
    - Control measures
- Market approach
    - Market analysis
    - Contract formation including control
    - Tender form
        - Selection
        - Award criteria
- Planning
    - Activities
    - Milestones
    - Go / No-go

Especially the type of tender is important where RWS, especially for large projects at GPO, chooses for a Design & Construct (D&C) contract or a Design, Build, Finance & Maintain (DBFM) contract.

Design & Construct:
In this contract the contractor is responsible for the design and the execution. In the contract a description of the project is given together with the program requirements. RWS tests the design, quality and construction methods on the basis of the requirements that were formulated.

Design, Build, Finance and Maintain
The contractor takes responsibility for all parts of the project: design, execution, financing and the maintenance. Depending on the contract the contractor is responsible for 20 or 30 years of maintenance.

Looking at the different types of large projects GPO is dealing with different phases, from the planning until the exploitation phase. An overview of the projects updated on the 9th of December 2015 was retrieved, see appendix I. In total 34 projects and the related type of contract were described. For most projects in the future the type of contract is not yet determined. A type of contract which doesn't occur very often but in the overview occurred 2 times is the PD&C which is a D&C-contract where additionally the planning phase is integrated. The rest of the contracts were mostly D&C-contracts (19 times, 56%) and DBFM-contracts (13 times, 38%). Another point of interest is that there was one program described, the Schiphol-Amsterdam-Almere program (SAA) which includes 5 contracts of which 4 of them had a DBFM-contract. These DBFM-contracts often give more space for the implementation of product innovations whereas the contractor is responsible for the whole project and is more

focused towards the life cycle costs since he is also responsible for the execution and maintenance. Innovations should therefore reduce the life cycle costs unless they are rewarded in a tender of RWS, otherwise contractors are less likely to apply a product innovation. Also DBFM-contracts often describe more functional specifications instead of technical specifications leaving more space for innovations to be applied.

Phase 5: Assessment

Then the tendering (procurement) process will be held with different parties who did an offer. RWS assesses the offers on quality and price whereas the award criteria can give a fictive price discount if they are achieved by the contractors which would give them an advantage to win the tender.

Award criteria - MEAT

The definition of MEAT was changed after the new procurement legislation on the 1st of July in 2016. MEAT It is now the definition for 3 award criteria:

1. Best value for money ratio (in Dutch: beste prijs-kwaliteit verhouding, BPKV)
2. Lowest costs on the basis of cost effectiveness (lifecycle)
3. Lowest price

Quality is described as e.g. more focus on the public orientation, sustainability and risk management. Via MEAT-criteria RWS tries to contribute to societal challenges where the implementation of innovations could help contractors in order to achieve different goals. The BPKV is set up from the goals and risks of a specific project. Related to it is the Best Value Procurement which is used to let a contractor add maximum value in order to differentiate themselves from other contractors with lower costs in the tendering phase. Best Value Procurement (BVP) is used for engineering services and for D&C-contracts. Conditions of BVP are:

- Sufficient competition in the market
- Sufficient risks for RWS on which the contractor can differentiate
- Functional request (the more competitive advantage, the better)
- Client lets go, minimal validation and proper attitude and behaviour
- Contractor shows craftmanship and makes results transparent

Note that sufficient competition can be an issue when a product innovation was developed by one contractor who doesn't sell the product to their competitors.
The IPM-team of RWS will set up the MEAT-criteria for a project together with an advice of a procurement advisor. These criteria will be judged in the received offers from the contractors. Independent teams first judge the quality criteria within the MEAT which is done by employees of RWS who are not familiar with the price. After the qualitative judgement have been taken place the registration fees of the contractors are coupled. RWS controls the MEAT-criteria during the execution of the project, if a criteria wasn't met a sanction of 1.5 times the value of the criteria have to be paid as a fine. The added value RWS wants to receive is expressed as a (fictive) "monetary value" in euros. The monetary value shows what RWS wants to give for the added value provided by the contractor. The criteria has to be easy to understand and differences between quality outcomes have to be measurable during the judgment and in the realisation and/or exploitation phase.

Phase 6: Execution

In this phase the winning offer from a contractor or a consortium (different companies such as multiple contractors and/or an investment company combined) may execute the tender. Together with the IPM-team the contractor or consortium can execute the tender whereas on the basis of the contract the roles and responsibilities are clearly communicated between RWS and the executive party.

Phase 7: Completion
If the work is done RWS will evaluate the work and will determine if the contractor(s) did what they offered and promised to do.

Phase 8: Managing and Maintenance
The maintenance of the highways is one of the main tasks of RWS. Therefore most projects have separated maintenance contracts related to a performance contract. DBFM is different whereas it already integrates the maintenance in the total project and offer.

6.4 Status quo procurement of innovations at RWS

Climate change, an infrastructure that needs to be replaced, increasing traffic flow, the development of information technologies, all topics that influence the need for the ministry of I&E to change their workings processes and products that are used in road construction projects. Innovations can be developed and implemented to achieve societal goals and when scaled up also potentially in a faster pace. Current product developments often achieve little added value in order to achieve those goals. But the availability and safety of the roads still have to be accounted for so it is a very time consuming and a slow progress to adjust standard solutions, regulations and legislations. To create an understanding of overarching goals to which innovations have to contribute to RWS formulated the following goals:

- 30% lower life cycle costs
- 30% more sustainable and/or safer
- 30% more functionality

All these goals are still very vague which makes it difficult to understand what exactly the needs are especially on a product level within road construction projects. RWS formulated 5 main pillars to look at which questions and challenges they need to focus on related to innovations.

1. International (Horizon 2020)
   Focusing on networking for urban vitality, cooperative information technology corridors, asset management for European infrastructures, infrastructure innovation through pooled funding, water, climate and a circular economy.
2. Top sectors
   The policy of the top sectors have improved the knowledge and innovation within the Netherlands. The market got a more prominent role in the direction and control of the top sectors.
3. Collaboration and alliances
   RWS works together with provinces, municipalities, water authorities, market parties, knowledge institutions, non-governmental organizations and stakeholders. RWS divides incidental and long-term collaborations with a more structural form. Co-creation and open innovation is stimulated by RWS to develop solutions for existing problems. The Bouwcampus is initiated by i.e. RWS, several municipalities, TU Delft and Bouwend Nederland. They compare challenges they have such as the infrastructure, energy-neutral solutions and the environment.
4. Public Procurement of Innovation (in Dutch: innovatiegericht inkopen)
   This instrument is intended to stimulate the procurement of innovations by giving innovations space in tenders such as to describe specifications more functionally.
5. Innovation proposals via “Servicedesk Zakelijk”
   It is a window for the market to come up with proposals. They will be tested on their content related to their question and proposal.

RWS looked at the relevant developments and trends in their working field and described an **innovation agenda** (for 2015-2020) which they communicated with the market. It lets the

market know where the focus will be towards the primary processes of RWS, (Innovatieagenda 2015-2020, 2014). The innovation agenda formulated the next 10 points:

1. Water safety
2. Water management
3. Traffic management
4. Construction and maintenance: add value
5. Replacement objective of the infrastructure
6. Asset management
7. Synchro modality
8. Living environment
9. Information supply
10. Societal challenges

RWS is continually looking for smart, sustainable, safe but also more affordable ways to make our country safe, accessible and liveable. To signal, stimulate, facilitate and connect innovations to concrete projects the **Corporate Innovation Program (CIP)** was set up. They facilitate and support the innovation agenda. The program couples different parties from inside and outside RWS to create and share ideas, experiment and share results. RWS shares their information with the market to learn from each other and also to stimulate contractors indirectly to develop, buy and implement innovations whereas they don't want to stay behind current developments. In their yearly overview of 2017 the CIP formulated 70 innovations that were brought a step further in the innovations process the last years together with market parties and knowledge institutions. The CIP was focused around 6 clusters: Innovation management (1), Infra and Mobility (2), Water (3), Space and Environment (4), Information supply (5), and the Innovation Test Centre (6), see appendix J. Each of the clusters will be discussed in relationship to product innovations in the road construction industry:

1. ***Innovation Management:***
   To streamline the innovation process within RWS this cluster focuses on instruments to empower innovations to be developed, adopted and applied. Three important instruments will be described:
   - *Innovation-Urgenda*
     Focuses on the biggest barriers for innovations around different topics. It focuses on departments, projects and programs of RWS. Some key persons towards innovation were asked to make presentations about innovation in the chain and innovation processes at RWS together with 4 cases which were discussed in a group session. The session provided some general barriers and some suggestive challenges such as a focus point in the future and working more towards the whole chain. In 2018 they want to come up with a definitive approach to cope with the barriers.
   - *Flexibility with the Scope Challenge*
     Is an approach that acts independently from the objectives and on behalf of the joint interests. The goal is to get all project stakeholders to look broader than the scope.
   - *Innovation Route Planner*
     Within the CIP they are currently working on this assessment tool. This instrument can be used for innovators as well as for the end users of an innovation. It describes the Technology Readiness Levels 1 to 9 to see how developed and applicable the innovation is for projects of RWS. They also focus on the stakeholder readiness level (SRL) to implement the innovation. It looks at aspects such as the added value of the innovation, support and commitment, costs, suitability and risks. The goal is to get attention in an early stage for organizations and their environment to deal with the innovation in

order to be applied (in a faster pace).

2. ***Infra and Mobility***
   RWS focusses on a good traffic flow and to use the current infrastructure more effectively and efficiently. Besides mobility, topics such as safety and sustainability also have an important role. RWS looks for new materials such as the ultra-silent road, recycling and complying to goals related to climate change. Some of the focus areas RWS is currently working on with the market are:
   - Lifetime-extending maintenance of ZOAB
   - Ultra-silent asphalt
   - Infravation
     Collaboration with 9 European countries, the United States, Israel and RWS as a coordinator. Goal is to pace up the speed with which innovations are developed and can be applied.
   - Climate-proof networks. The climate changes and extreme weathers are more present. A model is being developed together with Deltares, TU Delft, TNO and the market to predict disturbances on the road related to the extreme weathers and to share the knowledge to improve the construction and maintenance of the road network.

3. ***Water***
   Is not the focus of this research but is in many cases related to road construction projects so it has to be taken into account for each type of product innovation what the relationship is. CoPS products such as the under layer of the road or a bridge can have an influence on water related objectives or products and vice versa.

4. ***Space and sustainability***
   RWS focuses on a sustainable, clean and healthy living environment. They are doing this by i.e. focusing on generating sustainable energy, stimulate sustainable mobility, focusing on circular materials and supporting biodiversity. A lot of innovations related to these topics are being developed and slowly implemented. Some important focus areas RWS is working on related to the road construction projects are:
   - A37: solar route of 40 kilometre
     RWS investigates with the surrounding municipalities, the province Drenthe and network operator Enexis what possibilities there are to generate solar energy. It should contribute towards an energy-neutral road in 2030 which is one of the goals.
   - Solar Highways
     Noise barriers are extremely useful to generate solar energy. Therefore RWS is looking how solar panels integrated in the noise barriers can be constructed and if it still contributes to the reduction of carbon dioxide. At the A50 (Uden) a noise barrier with 400 metres length and 5 metres height will be supplied with 1600 square feet of solar cells on both sides of the barrier.
   - Biodiversity and solar panels
     Solar panels on the side of the road seems like a good effective solution. But they do influence the verge growth on the roadsides since less light and rain will reach the bank. Research looks at different solar panels and how it influences the biodiversity.
   - Indicator Circular Economy
     RWS wants to work circular in 2030. It means that all activities have to focus on circularity. The indicator looks at the current circularity of different objects, projects and material flows. They will also determine the technical starting points and in the future how it can be measured.
   - Circular engineering

Focuses on how the engineering of materials can be designed and executed towards circularity. Knowledge on this area has to be improved and effects of it have to be analysed and shared.

- Towards a “climate-proof” road network
  In 2017 the “Deltaplan Ruimtelijke Adaptatie” was determined. It means that the Netherlands have to be climate- and water-proof in 2050. A map with “blue spot maps” was made to show the locations of the main road network which could have disturbances due to the weather. Risks are now being evaluated and discussed to look at what measures can be taken to reduce these risks.
- Bio screen A15 (Tiel)
  RWS experiments a lot with innovative bio screens. In the “Green Deal Infranatuur” an agreement was made to increase the biodiversity in the Netherlands. RWS looks at how sustainable shores, roadsides and service places aside the road can be designed and managed.

5. ***Information supply***
   Developments around information are changing fast. To investigate the potential and the usefulness of it several programs were set up. It is a collaboration with the market, government, knowledge institutions and civilians. Some examples of the programs are asphalt maintenance with big data, big data for traffic management, artificial intelligence and traffic management, virtual and augmented reality and InSAR (measurements with satellite radar images).

6. ***Innovation Test Centre***
   Before innovations can be applied in actual projects they need to be tested. The Innovation Test Centre (ITC) has an important role to test innovations from the market. They provide insight information about the risks and the validation of the product. Especially innovative asphalt mixtures were validated with a high level of re-used materials and/or asphalt with a low processing temperature. The expectation is that to steer more on sustainability these types of products will increase. Some of the product innovations are:
   - Diffractor
     Used at the side of the road to diffract noise to the nearby surrounding.
   - Low temperature asphalt (less energy and carbon dioxide)
   - Acrylic fibers for longer life span of ZOAB
   - Re-use of two-layered ZOAB
   - Lifetime extension for almost worn out ZOAB
   - Light-reflecting asphalt for less energy usage
   - Contest for safe edge constructions of ZOAB
   - Re-use of cleaned ash

   The ITC has some criteria before something can and may be tested:
   - It is innovative, different than the current standards
   - Provides opportunities for the core business of RWS
   - Expected to have a better price-quality than the current products
   - It can be available within a reasonable time (maximum of 4 years)
   - It is testable on relevant aspects

Nevertheless the ITC is not responsible for the product actually being applied in projects. They will inform the relevant members within RWS but the rest is up to the supplier and/or contractor. The question rises how and when members of the procurement department of RWS are involved to make space or to stimulate these innovations in future projects.

Innovation in road construction projects of RWS
Research was done by Ridder, de, Boer, de, Vries, de, and Jongejan (2011) to look at innovations in construction projects of RWS. The goal was to get information about the innovations that are developed and applied, how to increase them and how RWS could optimize their innovation process. The first important note that was described is that the ambition and the goal of the project are guiding and that innovation is not a goal on itself. Innovation should have a positive contribution to the results of the construction project. First point of attention is that it is often unclear what the specific (smart) goals of future projects are until a tender is formulated by the IPM-team which makes it hard to diffuse and implement innovations for contractors.
Ridder et al. (2011) saw that there were 5 reasons for an innovation to originate:

- To achieve the scope (project goals within the time and budget)
- Pressure from the environment
- Initiative from the market
- Initiative from the project team
- Imposed innovation

The scope was the most important trigger for innovations to originate. The scope is often described by the ministry of I&E who has the responsibility to achieve i.e. sustainable goals. The environment could also stimulate the need for an innovation to be developed and implemented where requirements and wishes from different stakeholders in a project can be of influence. Think of citizens who are unwilling to look at a wind turbine or a noise barrier which could lead towards the invention of new solutions and the application of product innovations. Initiatives from the market also occur where it is important for RWS to be open for those ideas and give space for them in tenders in order to be implemented.
In the project team a need for innovations could arise to achieve the project ambition or to solve certain problems. They could also stimulate the image of the project and create more support. Finally innovations can be imposed from higher up which could be the case when they have to deal with new regulations and legislations or when a clear innovations strategy was formulated by the management board.

Some innovations derived from interviews of Ridder et al. (2011) that were applied are:

- Noise absorbing constructions with volcanic rock
- Energy-neutral bridge
- Re-use of steel slag
- Other materials for temporary markings
- New type of joint (between the road and a bridge)
- Eco-guiderail

Looking at the innovations they are mostly developed as a result of politics, environmental policies or the market as opposed to technical possibilities.
Within the road construction projects the project managers gave themselves a 6.5 for being innovative with “pretty little” innovations applied which had a “reasonable impact”, Ridder et al. (2011). Looking at the technical innovations the market is taking the lead. The role of the project team of RWS is to stimulate the market in the right way, for example by brainstorm sessions to solve specific problems, by setting up MEAT-criteria to stimulate the implementation or to organise the tender in a way which gives space for the contractor to apply an innovation.
At RWS the project team finds it hard to collaborate between departments and to convince employees about the use of an innovation and therefore to let them step away from current guidelines and rules. Here the role of several members of a social system is emphasized. Changes are not often implemented, it is therefore important to communicate with all relevant parties in an early phase of the innovation process. In that way they will slowly become committed and feel like co-owners. It can change their attitude and will make them change working processes in order for a product innovation to be implemented again and to scale up

in future construction projects. On the other hand risks related to innovations often lead towards discussion within the scope of a project. The decision of top management is often necessary to get things through. Also for project teams it is not always clear at which specialist and organization wide window they need to go in order to acquire or assimilate knowledge of product innovations.

Ridder et al. (2011) also described the diffusion of innovations among projects. For proven innovations RWS could focus more on knowledge sharing to increase the implementation of innovations between projects.
For RWS it is highly important to act in a legal way during the execution of their projects. There are a lot of rules to which RWS needs to comply to. The emphasis lies towards controlling and managing a project while achieving the goals. The scope management eventually determines what the project does.

Looking at the products applied in road construction projects, there is a strong tendency towards standardisation which implicitly means that no (new) innovations are wanted. Most innovations are initiated from within the scope of the project which is something else than letting the market innovate and be the source for new innovations. RWS therefore needs to involve and use the market as a source to define future scopes and related goals. Stimulating and rewarding market parties if they do implement innovations is therefore important. The research also saw that DBFM-contracts gave more space for innovations. Ridder et al. (2011) concluded that there was no systematic cost-benefit analysis for innovations. It could be helpful to set up standards and measuring techniques in order for the IPM-team and the procurement department to know which product innovations could be beneficial in achieving the project goals. They could also measure MEAT-criteria better and adjust them in order to stimulate contractors to focus on the added value of their product innovations. Many times qualitative estimates were done without hard facts and figures.

6.5 Stimulating product innovations to scale up in tenders

RWS mainly focusses on TRL stages 7 and 8 related to the testing and validation of product innovations, which is contributed by the ITC. Furthermore they stimulate public procurement of innovations in their tenders and even make it a project goal such as for the InnovA58, Solar Highway and the Road of the Future (N329 in Oss). If the product innovation was validated RWS could then act as a launching customer and user of the product.
Looking at the innovations, RWS describes the innovation agenda on a high level such as to add value in the construction and maintenance of projects, asset management or societal challenges. They described for all innovations to focus on a reduction of 30% on the life cycle costs, 30% more sustainability or 30% more safer, and 30% more functionality. Taking the MIRT into consideration and how RWS describes the goals on different topics such as sustainability and circularity, there is no clear focus towards certain types of products, product groups or a whole set of products and systems (CoPS). There are also no smart goals described on a product or product group level. What is the goal of circularity in 1 year or 5 years for different types of products or product groups? Should it result in 30% lower life cycle costs but also 30% more sustainability and safety, and 30% more functional? And what does safe, sustainable and functional even mean, which standards or reference points for each products should be taken into account? It is hard for the market to know what exactly is desired, in which tenders it will be able to be applied and how is it measured and/or rewarded.

To manage the innovations the CIP set up the Innovation-Urgenda, the flexibility with the scope challenge and the innovation route planner. Focusing respectively on the barriers for innovations, creating a broader perspective than the scope of one project, and to make an assessment tool for suppliers and the procurer (RWS) to see in what stage of the innovation

process a product innovation is (TRL) and how ready the stakeholders are to adopt and implement it (SRL). Especially the latter is important in the innovation-decision process whereas the decision-makers are not only those of the supplier/contractor but also other contractors and RWS. For a radical product innovation it could very well be that several companies are not ready due to competences they don't have or they are resilient to learn.

Diffusion process

Looking at the diffusion process of an innovation not only the contractors but also RWS needs to cope with the innovation and has to deal with it. RWS can stimulate and support innovations and diffuse the knowledge related to it among members of the social system. First of all the characteristics of the innovation are very important for an innovation to be adopted and implemented. Especially the relative advantage and the added value which the product innovation has for the contractor, RWS and the users is very important. RWS formulated some 30% goals for example but these are not really useful to apply to all types of product innovations.

RWS tries to focus more and more on being a facilitator for innovations in different TRLs including the support to create and shared knowledge within the market. Some examples of programs that were set up are the lifetime-extension maintenance of ZOAB, multiple-year noise reduction related to the ultra-silent roads and the indicator circular economy. For creating and sharing knowledge RWS initiated the Bouwcampus with several municipalities, TU Delft and Bouwend Nederland. It is necessary to discuss with peers what possibilities there are and how they can be achieved.

Time is a continuing factor which has to be taken into account whereas requirements and wishes change over time, innovation-decision processes can occur several times with different members of a social system. A product innovation can eventually be standardized which will let contractors embed the innovation as a dominant design resulting in the upscaling of the product. Via programs and projects RWS stimulates certain topics and societal goals to be achieved and therefore innovations to be developed, applied and scaled up.

Antecedents for scaling up product innovations

Looking at environmental factors described in the theoretical framework as antecedents, some of them which RWS currently uses will be discussed.

In the first place, for contractors or suppliers of a product innovation to develop, adopt and implement a product innovation the **environmental pressure and -policy** is an important stimulant. The ministry of I&E and RWS explicitly describe demands such as energy-neutral roads in 2030 with possible solutions such as solar cells at the side-roads and solar cells integrated in the noise barriers. Furthermore the carbon dioxide reduction and circular economy are mentioned whereas for the carbon dioxide DuboCalc is the standard to measure it, whereas for the circular economy an indication is currently being made in order to measure products in the future and award them. It will stimulate contractors to adopt and apply more circular products and even product innovations. These stimulate the market to develop, adopt and implement these types of products. To scale up there is a lack of coordination whereas RWS or the MIRT doesn't describe smart goals of future projects for certain types of added value related to product groups and/or CoPS. No clear roadmap or "application route" was described by RWS which makes it difficult to determine the market potential for product innovations in the long run. When and where the product may be implemented in each TRL is not clear, especially after TRL-9 when a product innovation can be scaled up.

Therefore the **requirements and wishes** are not stimulating the upscaling of product innovations and prevent diffusion and adoption to take place. Product innovations are therefore not embedded as a dominant design and lack upscaling.

Looking at the **inter-organizational relationships** the market is working together more often in order for knowledge to be created and disseminated among the members of the social

system. A focus on overarching goals such as noise, sustainability, circularity and energy-neutral building are described.
The **coordination and integration** of stakeholders within the sector is still a point of interest. It is a good way to stimulate the upscaling of product innovations when smart goals for future projects are described. An example where RWS coordinates and integrated stakeholders is the SmartwayZ.nl. It relates to national policies and consists of the government, provinces Brabant and Limburg, several municipalities, the market and knowledge institutions. It focuses on:

- Optimal life cycle costs for construction and maintenance
- Less environmental pollution and an energy-neutral road
- New services aside the road
- Smart techniques such as C-ITS and Smart Mobility in relationship to the mobility program of SmartwayZ.nl

One of the projects related to the SmartwayZ.nl, which was used as a living lab, was InnovA58 where innovations could be tested and applied.
Looking at the program, it is still difficult to know the market potential of product innovations in projects whereas municipalities and provinces normally have small projects including a RAW-contract that prescribes a lot of technical specifications.

The organizational factors can determine whether or not an innovation is wanted, (in)directly asked for in a tender and if sufficient knowledge is communicated in order to cope with the innovation. First of all **the resources** of RWS are important to analyse. RWS is spending time and money to work together with the market even more so they can learn from each other. Knowledge is acquired via the ITC and via different programs and instruments described by the CIP. As mentioned by Gerling (2014) inter-project learning is not systematically integrated where it leaves procurers and IPM-teams with uncertainties whether and how to stimulate new product innovations, change their VSE and how to manage the risks related to it. If knowledge towards innovation is systematically captured on a product or CoPS level the output and outcomes of the product in each tender can be analysed. The information can then be diffused to learn and inform RWS employees in different departments. Especially the procurers who set up the procurement plan and the IPM-team who can stimulate innovations to be applied via the MEAT-criteria and project goals. It can increase the potential of scaling up product innovations.

Tender
A instrument to stimulate the implementation and upscaling of product innovations which RWS uses are the MEAT-criteria described in a tender. They can ask for added value and push contractors to develop product innovations in order to acquire a fictive price discount. Also the type of contractor and the specifications are very important aspects. A DBFM-contract for example lets the contractor focus more on the total life cycle of a product which could stimulate innovations to be applied. The DBFM-contract is also more often functionally specified giving a contractor space to develop their own solution and to apply product innovations where possible and necessary. Innovation on itself is not important whereas the relative advantages or added value of the product innovation for the contractor, RWS and the users are of more importance.
The fictive price discount that can be achieved by the MEAT-criteria can stimulate innovations to be applied when they are making a difference for contractors if they do so. Some projects can stimulate innovations whereas they specifically describe innovation as a goal of the project such as for the InnovA58 project.
Furthermore the contractor has the ability to propose a “Voorstel tot Wijziging” (VTW) which could be to implement an innovation, after the winning offer was determined, in a contract. Often it will not be approved due to the risks and consequences the IPM-team has to deal with. Occasionally RWS discusses a project in an early stage with the market. The

competitive dialogue and the market consultation are two instruments which are used to determine possible solutions, the scope of a project, MEAT-criteria to be adjusted and so on.

Looking at the innovation level and individual level antecedents, further research have to be done towards their relationship with specific product innovations in different projects. The social system can differ between each project such as the IPM-team of RWS and a project manager and/or engineers of the contractor. It can lead towards different innovation-decision processes over time. The environmental and organizational factors can also change the conditions and requirements within tenders. Different projects should be analysed to see when a product innovation was stimulated, how and why it was embedded in the design and if it is embedded as a dominant design (applied in the solution in more tenders) by the contractor(s).

6.6 Conclusion

In general RWS mainly focuses on the testing and validation of product innovations, TRL-7 and TRL-8. On a small scale they also focus on TRL-9 where they act as a launching customer but a lack towards upscaling of product innovations is seen, TRL-10. Especially between RWS as a sponsor and regulator versus a buyer and user innovation is not really coordinated on specific products or CoPS especially towards future projects. For each role some conclusions are described on how they influence the upscaling of product innovations.

Sponsor
Looking at RWS as a sponsor they stimulate different topics such as sustainability. It is communicated and executed via i.e. programs such as an energy-neutral road and a circular economy but also on a more product level such as the life-time extension of ZOAB. The ministry of I&E also describes future projects and programs on a national and some regional levels. The ITC facilitates and stimulates innovations to be developed, tested and applied in pilots until TRL-8. Furthermore RWS facilitates information sharing and creation of i.e. the Bouwcampus which is necessary to involve the market in current and future developments and challenges in order for the market to deal with them.

Regulator
It is inevitable that regulations and legislations differ between projects which makes each project unique. As a regulator RWS is reluctant in changing regulations and legislations. They want to retain a safe and qualitative road and avoid risks related to innovations. When a tender was written RWS doesn't often change it during the tendering phase which could make contractors less willing to apply and scale up product innovations. Also the tendency to standardize products is increasing which could stimulate the upscaling of a product innovation but prevents other product innovations to be applied, especially new and radical innovations.

User
As a user RWS focuses on i.e. self-driving cars but also towards the safety of the users and several other aspects. Overarching focus areas are defined but often smart goals are missing which could be related to the added value of product innovations. Noise reduction is one of the issues which is very specific but still not really smart on when and where it has to be achieved and so what the market potential is. It makes it difficult to sell the innovation towards contractors since the business model is vague looking at the financial benefits.

Buyer
The most important role which RWS has is the role as a buyer. As a buyer, especially for large projects executed by GPO, they need to comply to European procurement legislations. RWS stated that they want product innovations which have 30% lower life cycle costs, are

30% more sustainable and safer, and 30% more functional. They also described an innovation agenda where contractors can focus on. On a product level though these goals and focus areas are not really clear nor consistent. A consistent policy in the MIRT describing the added value of (groups of) product innovations is also lacking together with rewarding criteria in future projects. Coordination with provinces and municipalities is also a point of interest where the upscaling potential and the willingness of contractors to diffuse and adopt innovations can be increased. Smart goals on a product level are for most products not defined or communicated leaving firms with uncertainties about the market potential and the return on investment. Diffusion and upscaling is therefore prevented or at least slowed down.

Tender

In tenders RWS can stimulate the implementation of product innovations via several ways. Generally speaking they can make space for innovations to be applied, can ask directly for innovations via specifications, standardization or can describe innovations as a goal of the project such as for the InnovA58, or RWS can ask indirectly for innovations via MEAT-criteria related to the price-quality characteristics.

The type of tender is also important whereas 56% of the GPO-projects are D&C-contracts and only 38% are DBFM-contracts. The latter often gives more space for innovations, via functional specifications, to be applied whereas the contractor is then responsible for all aspects of the project focusing more on the TCO of a product.

MEAT-criteria can stimulate innovations to be applied where added value or relative advantages of a product innovations can be rewarded to acquire a fictive price discount which can result in winning a contract.

The tendering process, where first of all the ministry of I&E describes a track decision, isn't structurally supported by data of proven product innovations. There is no input of data related to proven product innovations when formulating the track decision nor with the formulation of the procurement plan, goals of the project and MEAT-criteria.

Looking at the upscaling of innovations Gerling (2014) already saw that there was a lack of systematic learning between projects especially towards cost-benefits analysis of product innovations. No cost-benefits analysis are structurally gathered and communicated towards different members of RWS where for the procurement plan the procurement department and the IPM-team could benefit from. They could then make space for innovations which could help in achieving the scope and goals of the project, adjust regulations and legislations if possible and needed, and stimulate innovations to be applied via MEAT-criteria which result in distinctive outcomes.

Antecedents

In general RWS can stimulate the upscaling of product innovations via environmental pressure and policies. Regulations and legislations have to be made more flexible or adjusted within contracts so that product innovations can be applied.

Requirements and wishes especially towards future projects are important for the upscaling of product innovations in order to define a clear business model for the adopters of the innovation leading to more insights in the financial benefits and market potential it could have. It is inevitable that requirements, wishes but also legislations and regulations change between projects but with some preliminary research, coordination between RWS, provinces, municipalities and water authorities and communication with the market some realistic (smart) goals could be defined for future projects that can stimulate the diffusion and implementation of certain product innovations.

Members of a social system within RWS focusing on a specific product innovation should be involved in an early stage of the innovation process of a product innovation in order to make space in a tender and stimulate added value in a project which could be achieved by applying a product innovation. Communication with the procuring body, multiple key decision-makers within different departments of RWS, is important for contractors and

suppliers towards topics and specific products or CoPS levels.

Instruments
Looking at important instruments RWS uses which can increase the implementation and upscaling of product innovations the following are important to take into account:

- **MIRT**, together with the ministry of I&E future projects but also programs are described on several topics that can stimulate the development and implementation of product innovations.
- **Corporate Innovation Program (CIP)**, was set up to signal, stimulate, facilitate and connect innovations to projects of RWS. They steer several instruments related to product innovations. On a product innovation level the ITC focuses especially on the testing and validation whereas the cluster Infra and Mobility and Space and Sustainability are focusing more on the development of products such as lifetime-extension of ZOAB, ultra-silent roads, circularity, and biodiversity.
- **ITC**, in essence tests innovations but also informs members within RWS about the innovations and communicates innovations in different TRLs with the market.
- **Public Procurement of Innovations (PPI)**, focuses on stimulating the procurement of innovations at tenders of RWS such as to give space for innovations in tenders.
- **Service Desk Zakelijk**, tries to see if an innovation (in different TRLs) can be applied in future projects. Sometimes tries to connect an innovation towards the market in order for them to deal with the innovation.
- **Innovation agenda**, describes on a high level where RWS is focusing on, which the market can use as a guidance. Nevertheless these are not really smart goals which can be directly related to a product or product groups/CoPS.
- **Knowledge creation and sharing**, on several topics RWS and/or the ministry of I&E set up programs. Bouwcampus is also used to stimulate innovations, which is a neutral place for contractors, clients, and knowledge institutions to collaborate in different ways to create innovative solutions and share knowledge.
- **Innovation Urgenda**, is a recent program which looks at barriers for innovations to be implemented. It concluded that there is a lack of focus towards a point in the future for innovations which is reflected by the broad topics in the innovations agenda and no clear roadmap for product innovations to be applied in future projects.
- **Scope challenge**, is an approach that acts independently from the objectives and on behalf of the joint interests. The goal is to get all project stakeholders to look broader than the scope.
- **Innovation route planner**, is an assessment tool which is being developed. It looks at the different TRLs a product innovation is in and tries to make the stakeholders readiness level measurable (SRL). It is a good start to understand if the social system of a product innovation is ready for the product innovation in order to be scaled up.
- **Programs**, can stimulate product innovations being developed, adopted and implemented. They can even relate to specific projects such as the SmartwayZ.nl and the InnovA58.

On several topics a lot of attention is given and is even steered by RWS in order for product innovations being developed and implemented. These are often related to asphalt or are defined on a higher level such as energy-neutral, sustainability, biodiversity or the circular economy. A lot of product levels or CoPS are not described on a smart level and lack clear market potential in future projects. It is often unclear where to go to even for employees of RWS towards colleagues and they also mention that convincing their colleagues is hard. Therefore it is important that knowledge in shared and key decision-makers of different departments are involved in an early stage (different TRLs) to make them committed and feel co-owner of a product innovation in order to slowly adjust working processes.

Chapter 7. Conclusion

The main question of this research was how RWS could influence the upscaling of proven product innovations in road construction projects, especially looking at large projects of GPO. When looking at the definition of product innovation it could differ for an individual, group or organization as their perception can vary of what is new and what the added value is towards a contractor, RWS and/or the user(s). To get from TRL-9 (successfully applied) towards TRL-10 (upscaling) some important characteristics of a product innovation can be described:

- Embedded as a dominant design at the contractors;
- Meet performance and reliability requirements;
- Meet the consumers' demand for a broad range of projects.

Since there are a lot of individuals and organizations involved it is a very difficult and complex situation to achieve whereas these characteristics can vary for each contractor or client and change over time.
In essence it means that the contractor is willing to diffuse and/or adopt and implement a product innovation since it can be applied in future projects and can help them win a tender. It also means that RWS should make space for product innovations to be applied and should stimulate contractors to apply product innovations that have a certain amount of added value which is needed to achieve the desired scope and goals of a project and overarching societal goals written by the ministry of I&E.

First of all in order for a product innovation to scale up diffusion should take place so that several contractors could potentially adopt and implement it as a dominant design. Looking at the current situation contractors often develop product innovations (with partners) only for themselves. Therefore diffusion doesn't take place which is necessary for a product innovation to scale up. It means that the innovation-decision process of other contractors often stop at the knowledge stage. Since most large contractors also work with their competitors in consortia they often hold their cards to their own and are afraid that their innovation will be copied rather quickly. Another important issue which could prevent the diffusion and so the implementation of a product innovation to take place is the fact that the demand for product innovations in a broad range of future projects is unclear together with the fact that too many restrictions occur within the tender. The uncertainty if a product innovation can be applied, when and in which projects leaves contractors with great uncertainties about the actual market potential, return on investment and potential profit of the product innovation. It makes the willingness to adopt and implement a product innovation very low. Therefore contractors are tend to focus on RWS and their programs in relationship to the adoption and application of product innovations such as the development of different types of asphalt. Most contractors don't have an innovation strategy probably due to all these described uncertainties. Also the fact that the competition is quite small for large projects and the tendering costs and risks are relatively high are making contractors reluctant and less willing to develop, adopt and implement product innovations which are not steered by RWS. Product innovations also have low upscaling potential between projects of public procurers which is seen as a barrier for contractors. Where public procurers such as provinces and municipalities, who account for around 96% of the total amount of km road in the Netherlands, are often prescribing technical specifications the upscaling potential is limited for innovations.

RWS should therefore describe a clear policy towards future projects and define smart requirements and wishes which could be related to product innovations directly via standardization or indirectly as a certain amount of added value which can be achieved by implementing a product innovation. Collaboration and coordination with provinces and municipalities can increase the willingness of contractors to diffuse, adopt and implement

product innovations when clear overarching goals are defined for future projects which gives contractors the assurance that proven product innovations can be applied. It can also stimulate small- and medium sized contractors to diffuse (sell) their product innovation to large contractors and vice versa if it is clear in which projects it may be implemented.

In order for a contractor to adopt and implement a product innovation RWS should make space in their tenders. The next factors were described which can decrease barriers for implementing product innovations and can stimulate the upscaling of them:

- Functional specifications instead of technical specifications.
- Type of contract used, whereas DBFM-contracts often give more space for innovation and stimulate contractors to apply innovations more than in D&C-contracts.
- Regulations and legislations should be adjusted more easily, which often prevent proven product innovations to be applied again in future projects.

Besides making space for product innovations to be applied RWS should also stimulate contractors to apply product innovations that contribute to the scope and goals of the project. Factors that were described by contractors that were important are:

- MEAT-criteria that give a fictive price discount for contractors who achieve a desired added value described by the public procurer.
- Clear measurement of MEAT-criteria is important so that contractors can measure the product innovation on forehand. RWS should also make clear what added value they want in future projects so that the business model for product innovations to be diffused, adopted and implemented can be formulated.
- MEAT-criteria should make a distinctive outcome whereas it is often rated moderately and a lot of criteria can be achieved by most contractors which doesn’t stimulate the adoption and implementation of product innovations.

In order for the market to deal with product innovations it is important that a company has the knowledge and competences in order to do so. A lack of qualified personnel, competences and innovative power in the market is seen to increase which will influence the ability and willingness of contractors to develop, diffuse, adopt and implement product innovations. Since contractors are becoming more specialized it is important that knowledge creation and -sharing will have great attention. RWS should facilitate it via i.e. the Bouwcampus on topics and products that contribute to their future requirements and wishes. RWS should communicate and discuss with the market what realistic targets are and how they can solve related risks and consequences that (potentially) need to be dealt with.

Chapter 8. Recommendations

Derived from the conclusion several recommendations can be described in order for RWS to influence the upscaling of proven product innovations in large road construction projects in the Netherlands. The most important issue for contractors is the fact that it is often uncertain if, when and where proven product innovations can be applied in future projects. Clear smart goals should be described for future projects together with the fact what added value will be desired and how it may be awarded in future projects. It will increase the willingness of contractors to develop, diffuse, adopt and implement a product innovation. To increase the upscaling potential RWS should collaborate with the ministry of I&E, provinces and municipalities to describe smart goals for future projects so that the market potential and business model for product innovations is more clear stimulating contractors to diffuse/sell and adopt the innovations. It could also lead to the development of more similar product innovations creating a level playing field, lower prices and potentially more innovations that can be bought with the same amount of money. It is therefore important that RWS makes space in tenders for proven product innovations and that they stimulate contractors to implement them.

Make space for product innovations
This can be done by applying more DBFM-contracts and/or specifying more functionally instead of technically. RWS should be more flexible in changing regulations and legislations that can prevent proven product innovations to be applied again. In order for RWS to change regulations and legislations before a tender is written they should gather data of proven product innovations that are applied in their tenders. In that way they have the knowledge of the costs and added value of proven product innovations which are available in the market and can see what regulations and legislations should be adjusted so that it can be applied. A systematic cost-benefit analysis can then be used as an input for the procurement plan. The procurement team and IPM-team can use it during the formulation of the tender which can be an integrated part of the public procurement of innovation by RWS.
Sharing knowledge and information about proven product innovations should be done on a structural basis between project teams and relevant key decision-makers in the market to learn and evaluate the outcomes. It should be integrated in the working processes of RWS in order to learn from each project and to continually improve.

Stimulate product innovations to be applied
With the cost-benefit analysis the IPM-team can see which added value of different proven product innovations can contribute to the scope and goals of their project which is ultimately the main goal, not applying innovation on itself. They can also formulate MEAT-criteria which will result in distinctive outcomes between contractors that will stimulate the adoption and implementation of certain product innovations that will comply to these MEAT-criteria. Criteria that are not making a distinctive outcome should not be described in future projects. The outcomes should also be used during the formulation of new tenders and also in the requirements and wishes of future projects.
To measure MEAT-criteria RWS should describe standards in such a way that contractors can measure product innovations on forehand before a tender was written. It will stimulate product innovations to be diffused, adopted and implemented when contractors know what the financial benefits will be.
RWS could integrate a rewarding system for contractors that apply product innovations to stimulate the diffusion, adoption and implementation of product innovations.
Looking at the innovation agenda as an instrument it stimulates product innovations on a global level but it should be made smart with clear goals towards a product or product group

(CoPS) which can be measured. Related topics and programs should be described below each point of the innovation agenda to create a coherent strategy in achieving certain goals.

Ask (in)directly for product innovations
The most pivotal aspect in a business model of a product innovation to be diffused and implemented is the market potential and financial benefits it has. RWS should do a preliminary research together with provinces, municipalities and the ministry of I&E to look at future road construction projects and formulate a clear vision, smart goals and what added value in general will be rewarded in future projects. Collaboration and coordination between the clients towards proven product innovations is therefore very important. This first outlook can act as a guideline for contractors to get an indication about the market potential and financial benefits a product innovation has.
On some large topics such as energy-neutral roads, an indication can be made which possibilities are suited at each future project. RWS should discuss the goals with the market to see how realistic they are but still have to challenge them in a way it won't be achieved easily. Together with provinces and municipalities RWS should make a roadmap where product innovations can be tested, validated and applied for the first time and in which future projects it could potentially be applied. Servicedesk Zakelijk together with the department Market and Innovation of GPO, ITC and CIP can play an important role in setting it up for their own future projects.

Via pressure and policies from the ministry of I&E and RWS they can steer towards the development and implementation of innovations. They should create and share knowledge and information about important topics and innovations with the market. Programs are helpful to steer the market towards certain outcomes and to discuss them with the market to get a clear understanding about realistic goals and how the market can cope with new technological developments in future tenders.

Members of a social system, especially of different departments of RWS such as the procurement department, should be involved in an early stage at different TRLs. It will let employees of RWS from different relevant departments learn about the innovation, feel committed, become co-owner and change their working processes (slowly) in order to be able to adopt and implemented it in future projects. It also applies for suppliers of an innovations that want to diffuse their product innovation towards several contractors.

Chapter 9. Limitations and further research

A conclusion and recommendations towards the upscaling of product innovations for large road construction projects of RWS was written. Some limitations need to be taken into account and some focus areas for further research can be described. First of all little research was done between the relationships of the adopters, their characteristics, prior knowledge and the adoption of a product innovation. Different types of innovations were described in scientific research but different types of product innovations and their relationship with other products, components and CoPS were mostly not taken into account. Research also lacked findings on the relationship between the antecedents, barriers and stimulants, for implementing and scaling up product innovations. The sequence of stimulants and barriers should be further analysed. Did RWS stimulated innovations via “environmental pressure” first after which legislations where adjusted which changed the innovation strategy and the culture of a contractor? Resulting in the decision of contractors to adopt, implement and scale up a product innovation? Or did technological developments of contractors made RWS change their requirements and wishes after which they slowly standardized the technology in tenders to be applied. The relationship between antecedents and the time factor should be discussed in further research.
Further research should also focus on product innovations, how there are originated and if they were or weren’t diffused, adopted and implemented by contractors. Also the IPM-team of RWS changes over time which could be of influence the approach to make space for innovations, stimulate them via MEAT-criteria and/or make innovation a goal of the project.

Looking at the upscaling of product innovations it is also important that only large contractors and one medium sized contractor were analysed which could lead to an internal bias. Small- and medium sized contractors, sub-contractors, specialized road construction companies, engineering companies and suppliers (other than the contractor) could also be important for scaling up product innovations in several ways since they can influence each other.

The internal validity can be questioned whereas only one person of each contractor was interviewed who could answer the questions in a way which is most beneficial for their own company and developed products. More persons with different roles should be taken into account in further research to see if the outcomes are still valid and if innovation-decision processes differ between these decision-makers.
The suppliers of product innovations (other than the contractors) were not taken into account meaning that there could be innovations which are less relevant according to the contractors which did or didn’t scale up due to several reasons. In further research they should be taken into account to see if there are different stimulants and barriers to scale up their product innovation and how they diffused there product to the contractors.
Looking at the stimulants and barriers mentioned by the contractors in the interviews they were acquired at one point in time. It could very well be that other antecedents are important which they didn’t mention at first or that the importance of antecedents changed. They can also differ between product innovations and projects over time which should be taken into account. Characteristics of the company such as their internal competences and knowledge towards innovations should be considered as prior conditions which could lead to the rejection or adoption of a product innovation which can be analysed in the diffusion process of a specific product innovation.

Finally further research should also focus on the characteristics of key decision-makers and their social structure within a social system in relationship to the innovation-decision process which could influence their decision to embed a product innovation as a dominant design in order to scale up a product innovation in road construction projects of RWS.

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Appendix A – Stimulants and barriers to scale up a product innovation (theory)

A1 – Environmental stimulants to scale up product innovations

Stimulants	Description	Source
Environmental level		
Environmental pressure	Pressure such as media attention, political demands, and public demands.	Vries, de, et al. (2015), Fleuren et al. (2012), Cucciniello et al. (2015).
Environmental policy	Policy demanding suppliers to develop and implement products which are better for the environment.	Hojnik and Ruzzier (2015), Bossle et al. (2016).
Clear requirements and wishes	The client needs to clearly formulate what is really desired and wished for on the short- and long-term[1]. Especially asking for sustainable products has been proven to be effective[2].	Fleuren et al. (2012)[1]. Edler et al. (2011)2, Bossle et al. (2016)[2], Hojnik and Ruzzier (2015)[2].
Inter-organizational relationships – Participants in networks	The amount of relationships a person has outside of their own organization. It influences e.g. the information that is shared, the peer discussions and the communication towards product innovations.	Vries, de, et al. (2015), Oirschot, van, et al. (2010), Fleuren et al. (2012), Aarikka-Stenroos et al. (2014), Bossle et al. (2016).
Regulatory aspects	Regulations influences the way companies do their business and if product innovations may be applied.	Vries, de, et al. (2015), Bossle et al. (2016), Hojnik and Ruzzier (2015).
Subsidies, grants and taxes	A financial stimulus provided by the government for specific requirements of i.e. product innovations.	Hojnik and Ruzzier (2015).
Compatible organizations adopting the same innovation	The greater the number of compatible organizations adopting an innovation the more likely other companies will do too.	Vries, de, et al. (2015), Oirschot, van, et al. (2010).
Amount of competition	The amount of organizations within a sector can determine how severe the competition is.	Vries, de, et al. (2015), Oirschot, van, et al. (2010).
Amount of similar products	Describes the amount of substitutes available in the market for a certain product.	Fleuren et al. (2012).

A2 – Organizational stimulants to scale up product innovations.

Stimulants	Description	Source
Organizational level		
Slack resources	The company's size, personnel, knowledge, time, and money as the most important factors.	Vries, de, et al. (2015), Fleuren et al. (2012).
Financial advantages	Cost savings or -pressure and the potential revenue are some of the most important financial factors which could stimulate the upscaling of a product innovation.	Hojnik and Rozzier (2015).
Incentives and rewards	A culture of an organization where they extrinsically motivate employees financially.	Vries, de, et al. (2015).
Learning capability	The degree to which an organization is able to acquire, absorb and assimilate new knowledge and skills by e.g. training activities.	Ryu (2015), Vries, de, et al. (2015), Cucciniello et al. (2015).
Degree of risk aversion	Employees in an organization can be motivated to avoid risks and/or stimulated to learn, make mistakes and understand more about innovations.	Vries, de, et al. (2015).
Leadership styles	Political leadership and managerial leadership will define how employees are supervised and motivated to cope with innovations.	Vries, de, et al. (2015).
Top-management support	The amount of support from the top management can stimulate a decision-maker in his choices.	Hojnik and Ruzzier (2015)
Norms, roles and social networks	The firm's norms, formal hierarchies and informal networks determine the decision-making processes of their employees.	Oirschot, van, et al. (2015).
Requirements in the award criteria	It gives contractors the possibility to achieve fictive price discounts when complying to different criteria.	Edler et al. (2011).
Size and duration of a contract	The size of a contract and the amount of years can stimulate innovations to be applied and scaled up.	Edler et al. (2011).
Early supplier involvement	If the client interacts more with the supplier of a product innovation in an early stage barriers but also wishes and demands could be discussed.	Hojnik and Ruzzier (2015).
Isomorphism	A similarity of processes or structure of one company compared to those of other companies.	Cucciniello et al. (2015).
Communication about the innovation	The way people communicate and what they communicate influence how an innovation is diffused.	Oirschot, van, et al. (2010).
Degree of publicity to promote the innovation	The amount of publicity can stimulate employees to actively seek more information towards different types of product innovations.	Fleuren et al. (2012).

Company's image and reputation	Determines if a company wants to adopt and implement an innovation. It is related to their norms, values and beliefs.	Hojnik and Ruzzier (2015).
Influence of stakeholders	All companies that influences on an organization's business activities can determine whether a company adopts and implements an innovation.	Hojnik and Ruzzier (2015).

A3 – Innovation level stimulants to scale up product innovations.

Stimulants	Description	Source
Innovation level		
Relative advantage	Is the degree to which an innovation is perceived as better than the idea it supersedes. Especially focused on economic, social and environmental aspects.	Rogers (2003, p.15), Vries, de, et al. (2015) and Oirschot, van, et al. (2010), Hojnik and Ruzzier (2015).
Compatibility	Is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters.	Rogers (2003, p.15), Vries, de, et al. (2015).
Complexity	Complexity is the degree to which an innovation is perceived as difficult to understand and use.	Rogers (2003, p.16), Vries, de, et al. (2015).
Trialability	Refers to the degree to which an innovation may be tested on a limited basis.	Rogers (2003, p.16), Vries, de, et al. (2015).
Observability	Is the degree to which the results of an innovation are visible for the individuals of the social system related to a project.	Rogers (2003, p.16), Oirschot, van, et al. (2010).
Open technical standards	Technologies or innovations are available for every company resulting in more standard solutions where it can be integrated as a dominant design on a broad level.	Oirschot, van, et al. (2010).
Standardisation of the technology	The degree to which a technology is embedded as the dominant design and is a standard within the market.	Oirschot, van, et al. (2010).

A4 – Individual level stimulants to scale up product innovations.

Stimulants	Description	Source
Individual level		
Employee autonomy	It is the independence of an employee to get informed and eventually to adopt and implement innovations.	Vries, de, et al. (2015).
Job-related skills	The degree to which an employee has the knowledge and ability to cope with innovations.	Vries, de, et al. (2015).
Creativity	Creativity often relates to problem solving, where a creative employee is often more open-minded and able to solve problems.	Vries, de, et al. (2015).
Commitment	The degree to which an employee is binding himself/herself to a product or a specific goal to be achieved.	Vries, de, et al. (2015).
Job satisfaction	The degree an employee feels his/her desires fulfilled.	Vries, de, et al. (2015).
Shared perspectives and norms	The beliefs and standards of an employee can stimulate peer discussion but also convincing other members of a social system.	Vries, de, et al. (2015).
Homogeneous groups	Employees who have the same social characteristics and are therefore supposed to make the same decisions more often than heterogeneous groups.	Rogers (2003), Oirschot, van, et al. (2010).
Innovativeness	The degree to which an individual is relatively earlier in adopting new ideas than the other members of a system.	Rogers (2003, p.22)

A5 – Environmental barriers to scale up product innovations.

Barriers	Description	Source
Environmental level		
Legislations and regulations	Laws, principles and conditions to which a company and/or product has to comply to.	Fleuren et al. (2012), Vries, de, et al. (2015).
Social importance to scale up	The amount of social pressure from the public or stakeholders to scale up an innovation.	Fleuren et al. (2012).
Lack of demand for innovation from the procuring body	A low or unclear demand for specific innovations from the procuring body.	Edler et al. (2011).
Fragmentation of the industry and professional bodies	The degree to which organizations are separated into smaller companies and professions.	Kulatunga et al. (2006).
Isolation between contractors and engineering- and consultancy firms	A low degree of communication and collaboration between contractors, engineering- and consultancy firms.	Kulatunga et al. (2006).
Significant coordination and integration problems	Low degree of structured interaction and collaboration between organizations who have common or related goals.	Kulatunga et al. (2006).
Traditional channels of political communication	Communication which lack the use of new channels such as social media.	Cucciniello et al. (2015).
Amount of competition	The amount of organizations within a sector can determine how severe the competition is.	Vries, de, et al. (2015).

A6 – Organizational barriers to scale up product innovations.

Barriers	Description	Source
Organizational level		
Clear requirements and wishes of the client	A lack of clear requirements and wishes on the short- and long-term.	Fleuren et al. (2012).
Price is more important than quality	Tendency that price is still more important than quality in a tender.	Edler et al. (2011).
Degree of risk aversion	Employees in an organization can be motivated to avoid risks or stimulated to learn, make mistakes and understand more about innovations.	Edler et al. (2011), Vries, de, et al. (2015).
Learning capability	The degree to which an organization is able to learn new skills and knowledge by for example organizing training activities.	Ryu (2015), Cucciniello et al. (2015).
Norms, roles and social networks	The firm's norms, formal hierarchies and informal networks influences the decision-making processes of their employees.	Oirschot, van, et al. (2010).
Lack of management support	The (de)motivation of the management to adopt and implement innovations.	Long et al. (2016).
Poor management of risk	The way a company manages risk within a project.	Uyarra et al. (2014).
Slack resources	The company's size and the amount of personnel, knowledge, time, and money as important barriers.	Vries, de et al. (2015), Fleuren et al. (2012).
Financial disadvantages	High implementation costs, competing financial priorities, long pay-back periods, uncertain returns and results, and insufficient money are some important financial factors.	Oirschot, van, et al. (2010), Fleuren et al. (2012), Cucciniello et al. (2015).
Lack of interaction with the procuring body	There is little communication with the procuring body and little feedback on the procurement process.	Edler et al. (2011).
Procurement process is overly complex	The procurement process is too complex for a lot of organizations. Not quick and easy to deal with.	Edler et al. (2011).
Size and duration of contracts	Large contracts can be a barrier for SMEs since they often can't even compete. The duration could also lead towards higher risks for companies.	Uyarra et al. (2014).
Size[3] and structure[4] of the company	Amount of people in an organization and the hierarchical structure which makes them (in)flexible to cope with innovations rather quickly.	Fleuren et al. (2012)[3], Cuciniello et al. (2015)[3], Vries, de, et al. (2015)[4].
Organization and industry culture	All the knowledge and beliefs shared by an organization or industry.	Kulatunga et al. (2006).

Influence of stakeholders	All companies that influences on an organization's business activities can determine whether a company adopts and implements an innovation.	Hojnik and Ruzzier (2015).

A7 – Innovation level barriers to scale up product innovations.

Barriers	Description	Source
Innovation level		
Complexity	Complexity is the degree to which an innovation is perceived as difficult to understand and use.	Rogers (2003, p.16), Vries, de, et al. (2015).
Trialability	Refers to the degree to which an innovation may be tested on a limited basis.	Rogers (2003, p.16), Vries, de, et al. (2015).
Observability	Is the degree to which the results of an innovation are visible for the individuals of the social system related to a project.	Rogers (2003, p.16), Oirschot,van, et al. (2010), Long et al. (2016).
Scientific support of an innovation	The amount of scientific research which has been done on an innovation.	Fleuren et al. (2012).
Prescriptive specifications	A lot of tenders still have prescriptive specifications especially focusing on technical aspects preventing product innovations to be applied.	Kulatunga et al. (2006), Uyarra et al. (2014).
Life span/capital life	The amount of years a product can function correctly including maintenance activities if needed.	Long et al. (2016).

A8 – Individual level barriers to scale up product innovations.

Barriers	Description	Source
Individual level		
Innovativeness	The degree to which an individual is relatively earlier in adopting new ideas than the other members of a system.	Rogers (2003, p.22).
Lack of capabilities	A lack on experiences, knowledge and interests towards a certain innovation.	Edler et al. (2011).
The perceived risk aversion	Employees in an organization can be motivated to avoid risks and therefore learn less from mistakes and reject innovations.	Edler et al. (2011).
Heterogeneous groups	Employees in a group who have different characteristics.	Oirschot, van, et al. (2010).
Behavioural/psychological	A person's mental or personal characteristics influencing his or her decision-making process.	Long et al. (2016).

Appendix B – The road construction industry influencing upscaling antecedents.

The road construction industry influences the antecedents related to the upscaling of product innovations especially on an environmental-, organizational-, and innovation level. The individual level was not taken into account since it was less useful. The table still shows if the stimulants (St) and barriers (Ba) were described in the theory of chapter 3.

Antecedents	St	Ba	Stimulants	Barriers
Environmental level				
Environmental pressure and policy	Yes	Yes	Especially towards ecological topics it increases companies to adjust, develop and implement new product innovations.	Government's policy is not really challenging and consistent. Policy mix does not support the whole innovation process, especially between TRL1-8 and TRL 9+10.
Regulations and legislations	Yes	Yes	The government wants to set up regulations to increase transparency.	Rigidity in the application of legislations and regulations. The EU will continue to increase regulations and legislations on i.e. air quality, noise and habitat.
Requirements and wishes (demand)	Yes	Yes	Great upscaling potential for companies when innovation in RWS projects can also be applied for provinces and municipalities and vice versa. Scale reduction by diversification. More large projects are divided into smaller tenders. Opportunities for SMEs.	Large differences between RWS, provinces and municipalities. Not really coordinated and consistent related to overarching policy of the ministry of I&E. Scale enlargement by clustering. Small projects are more clustered, especially on local level.
Inter-organizational relationships	Yes		Knowledge assimilation takes place between client, contractor and institutions.	
Compatibility of organizations adopting the same innovation	Yes			
Fragmentation of the industry and professional bodies		Yes		Construction companies are becoming more specialized which makes it more complex. An increase in niche markets occurs. Consolidation makes the larger companies even larger.
Collaboration between contractors and engineering- and consultancy firms		Yes		Lack of chain collaboration. Weak trust level within the sector.

Coordination and integration of companies in the market		Yes		Between clients but also between clients and the market a lack of collaboration and coordination occurs.
Traditional channels of political communication		Yes		
Financial aspects	Yes		Private investors have more interest in infrastructural projects.	Middle- and long term prospects are still very questionable. Financial resources are important to stay viable for negative economic influences. Financial- and contractual options are becoming more complex. Disadvantage for large- but especially small- and medium sized contractors.
Amount of competition	Yes	Yes	Internationalization increases foreign contractors to compete in large projects.	Limited, only 10 large and some medium-sized contractors. No small contractors. Companies are increasing their business from a supplier to a full-service provider.
Amount of similar products	Yes		Due to standardization more similar product innovations will be developed increasing companies to lower prices and to invest more in innovations.	Due to an increase of standardization the amount of similar products will increase.
Organizational level				
Slack resources	Yes	Yes		Ageing and degeneration may lead to a deficit of personnel, knowledge and innovative power.
Financial impact	Yes	Yes		
Incentives and rewards	Yes			
Learning capability	Yes	Yes	Technologies such as automation, drones, augmented reality and BIM can increase the learning capability of an organization.	Decreases if a deficit of personnel and young professionals will remain.
Degree of risk aversion	Yes	Yes		The contractor and client are reserved in taking risks. The claim culture makes companies reluctant to take risks.

Leadership style / management support	Yes	Yes		
Norms, roles and social networks	Yes	Yes		
The contract (size, duration, specification and award criteria)	Yes	Yes	More integrated contracts occur such as D&C and DBFM which give more opportunities for innovations to be applied. MEAT-criteria is expected to increase some more.	The contractor has to deal with most risks since the contracts are becoming more integrated and include the finance and maintenance of a road.
Communication with the procuring body	Yes	Yes	A pre-competitive stage is used more often to learn from the market before finalizing the tender specifications.	
Isomorphism	Yes			
Communication about the innovation	Yes		Social media can inform the market faster and makes the market more transparent.	
Degree of publicity of an innovation	Yes			
Company's image and reputation	Yes			There is no reputation mechanism related to innovative companies.
Influence of stakeholders	Yes	Yes		
Requirements and wishes		Yes	Changes due to i.e. Horizon 2020 goals such as renewable raw materials and energy, circular products and an energy-neutral road.	
Price compared to quality		Yes	Tendency to focus more on quality instead of price.	Focus on TCO in tenders increases. Therefore focus on quality instead of price is still limited.
Procurement process		Yes		New tendering forms require knowledge on legal contract formation and risk management.
Organization and industry culture		Yes	A tendency towards a sustainable organizational culture keeps increasing.	
Innovation level				
Relative advantage	Yes	Yes	Technologies will improve the added value of products such as smart- and self-healing materials.	Sustainability increases the life span of products but challenges its relationship with other products which have a low life span.
Compatibility	Yes			

Complexity	Yes	Yes	Due to i.e. a focus on a circular economy products have to be easily disassembled.	Increases due to products and systems that slowly become integrated. For example ICT, Internet of Things, Big data, Augmented reality.
Trialability	Yes	Yes		
Observability	Yes	Yes	Especially chips, sensors, RFID and drones can convince others, decrease risks and reduce LCC.	
Availability of the technology	Yes	Yes	Due to standardisation technologies are becoming available for the market.	It will be harder for companies to create a competitive advantage. Can lead to focus on price instead of quality.
Standardisation of the technology	Yes		Standardisation is increasing which stimulates product innovations to be embedded as a dominant design.	It decreases the potential for new product innovations to be integrated as a dominant design.
Specifications in a tender		Yes		Especially RAW contracts prescribed technical specifications which prevents product innovations to be applied even if it was applied successfully once.

Appendix C – Questionnaire

Questionnaire - Upscaling product innovations in large road construction projects of Rijkswaterstaat.

1. Can you name product innovations that are successfully tested and validated in a pilot and have or haven't found broad implementation:

a) Innovations successfully scaled up:
..

b) Innovations that stopped after a successful implementation in a project:
..

2. The characteristics of a product innovation in general as described by Rogers (2003):

a) What are the most important relative advantages a product innovation should have?
b) Does an innovation need to be compatible in order to be scaled up in other projects?
c) Does the complexity of an innovation influence the choice to adopt (and apply) an innovation?
d) How important is the visibility of a product innovation for key persons before they adopt and apply an innovation in a project?
e) How important is observability of an innovation?

3. Communication channels

a) What communication channels do you use to get an understanding of the available developments and innovations in the market?
b) What communication channels do you use to inform the client such as RWS about innovations that you want to apply?
c) What formal ways do you use and what informal ways (face-to-face), and who is responsible for exchanging the information about innovations between employees in your company?
d) Do you have internal communication channels to inform employees about innovations?
e) What is important in persuading other members of your social system to learn and eventually adopt an innovation?

4. Time

a) How long does it take for an innovation to be fully implemented in your working processes in order to potentially scale up?
b) How quickly does your social system adopt an innovation?

5. Social system

a) Who stimulates innovations in your company to apply innovations in tenders?
b) Who are key persons to actually decide if these innovations are applied or rejected in a tender?
c) Does your organization focus on innovations to be applied and does the management stimulate employees to learn and adopt innovations?

6. Innovation strategy:

a) Do you have an innovation strategy concerning what innovations to focus on?
b) Do you also buy licenses of other competitors and do you sell licenses of your own innovations to other competitors?
c) How useful do you think the innovation agenda of RWS is for innovations in the road construction projects? Do you use it as a guideline for your own strategy?

7. Barriers to apply an innovation:
What barriers are there for a product innovation not to be applied in a tender?

8. Stimulants to apply an innovation:
What stimulants are there for a product innovation to be applied in a tender?

Appendix D – Companies and interviewed persons

Companies are normally divided by the amount of employees and their turnover. Since the combined information is useful whereas each company has a part of their workforce for large construction projects of RWS it is not useful to make the distinction. Nevertheless the amount of employees are derived in June 2016 from internet and interviews to get an impression about the total size of the company. Furthermore the contact persons are described which are interviewed and their function within the organization.

	Company	# Employees	Contact person	Function
1.	Van Wijk Nieuwegein b.v.	150	Stephan van Dalen	Executive Director
2.	Ooms Civiel (part of Strukton)	350	Frank Bijleveld	Researcher Road Construction
3.	Van Gelder	1000	Klaas Neeteson	Manager Strategy and Market
4.	Ballast Nedam	1899	Jan Niks	Division Director Ballast Infra
5.	KWS infra (part of Volker Wessels)	2200	Rinus Kok	Business Developer
6.	Dura Vermeer	2500	Anton Jansen	Cost expert (tenders)
7.	Heijmans	6412	Kristel van Haaren	Manager Sales & Business Development
8.	Volker Wessels	16000	Rob Jaeger	Program Manager
9.	BESIX	18000	Alexander Heeren	Commercial Director Infra
10.	BAM	19486	Ad van ‘t Zelfde	Business Developer

Appendix E – Interviews

E1 - Van Wijk Nieuwegein

Respondent: *Stephan van Dalen*
Function and company*: Director Execution (uitvoering) – Van Wijk Nieuwegein*
Interviewer*: Manu Klauwers*
Date: *21-07-2016*

Product innovations scaled up:
-

Product innovations not scaled up:
Product innovations are difficult for the organization since the company is too small to set up a research and development department. But they are trying to track all the trends in the market to know what is going on.

They currently are doing research for “schuimbitumen”. Which can be used for recycling asphalts.
They also work with Ballast Nedam to combine ideas, for example at a project in Utrecht to reduce the carbon dioxide with 50%.

Characteristics of an innovation:
They look at the advantage in the total supply chain, sustainability is one of these advantages.
It should be comparable or better than the current solution(s) on the market. Also the lifetime will be very important.

Relative advantage:
- Sustainability
- Costs
- Especially LCC

Compatibility:
-

Complexity:
For example products with plastic, rubber, et cetera which are not implemented in the core business of the company will not be preferred to apply or developed. They want to know more about it but they are too small to keep it running in their processes.

Trialability:
It should be a tested product. But if it is a tested product they would prefer to apply it in one of their own projects to test it.

Observability:
Is important because you are dealing with persons. A man first wants to see the car before he uses or buys it.

Communication channels:
They use professional journals, linked-in group(s) related to the developments in the road construction industry.
Internally they have the “Wijk Nieuws”, which talks about the innovations, the sustainability ladder and so on.
They are also connected to Knowledge Centre Asphalt, to develop asphalt which is funded by several companies and the knowledge is then shared. Around 30 persons, with 30 different opinions.

RWS should communicate more towards the market about information they know and what they really want to have in the future.

Time:
-

Social system:
Every person has his/her own ideas towards innovations and what is feasible and desired in the future. They also communicate with partners to solve a problem together.
Within the company they are open minded in applying innovations in their own working processes. They don’t develop the innovations themselves but have suppliers / partners to do it with or for them.

Innovation strategy:
They don't have their own R&D department or asphalt plant which makes it difficult.
They especially focus on sustainability but it should not be at the expenses of the lifetime for example.
The investments to develop new products themselves are too high which they currently can't afford. Furthermore the uncertainty of how many product they can sell in the future especially on the long term is a restriction for them to develop innovations.
Energy neutral roads will slowly become more demanded in contracts so they are also slowly investing and thinking about solutions to cope with it.

Barriers to scale up product innovations:

- Often can't comply to the reference requirements of projects that are demanded by RWS. For example the amount of asphalt realized in one single project. Therefore if they want to compete they will have to form a consortium with other companies.
- Can't reach the turnover that is needed for many large construction projects.
- The tendering costs are too high.
- Innovations should comply to a lot of restrictions which makes it impossible to implement it in a project.
- Information and opportunities are kept from each other, this happens at contractors but also at RWS.
- The fictive discount is in no relationship with the costs for an innovation in a project.
- MEAT does not always result in distinctive outcomes between contractors.
- A Technical Manager (or other person) could not believe in an innovation. Or doesn't want to adjust requirements for example.
- RWS also holds its cards and doesn't inform the market enough about information and technologies they are aware of or are developing/testing with TNO for example. So not very open and transparent.
- RWS is reserved in making appointments. They want to know why somebody wants to come. They are afraid that they are favouring a company which is forbidden. They often refer to the website to find information et cetera. Should make it easier for companies to communicate on certain levels, topics and projects.

Stimulants to scale up product innovations:

- A dialogue / market consultation could help to adjust requirements but in many cases RWS holds on to the existing ones.
- Innovation (sustainability) request via MEAT-criteria.
  A proposition is that 60% will be graded by MEAT-criteria and 40% by price. And dare to give a 4 or a 9 for a very good solution to tear the results apart if there is a real difference instead of a 7 or a 8. It happens sometimes but it may happen more often.
- Use functional specifications
- Make requirements more flexible to allow innovations but not to prescribe only one innovation (monopoly position).
- RWS, provinces, and municipalities should have more collaboration. A vision on the developments that are in line for all parties. A lot of roads are blended into each other.
  But nowadays highways are closed including a sloping road (in Dutch: afrit) and a bit later the same sloping road is closed due to maintenance of the province for example.

E2 – Ooms Civiel

Respondent: *Frank Bijleveld*
Function and company*: Researcher Road Construction - Ooms Civiel (part of Strukton Civiel)*
Interviewer*: Manu Klauwers (was filled in online)*
Date: *27-07-2016*

Product innovation scaled up:
Sealoflex modified bitumen (since the 80s)
Road Energy Systems (since the 90s)
OPA8 (3rd generation ZOAB) – since 2014, applied on A15 MaVa.

Product innovations not scaled up:
ML-TRAC (Rasenberg, sister-company within Strukton Civiel) – 100% recycling
Warm Mix Asphalt using waxes

Characteristics of an innovation:
Relative advantage:
- Extra quality
- Cost-effective (Life cycle advantage, total cost of ownership)
- Time-effective.

Compatibility:
Is often important. Road agencies barely dare to take any risks, especially RWS.

Complexity:
Technically complex is not by definition a problem, but if the possible consequences at failure are high it becomes problematic.

Trialability:
This is very important to create public- and political awareness and support.

Observability:
At the moment this is very important. Most agencies don't want to bear any risks.

Communication channels:
All channels possible such as professional journals, fairs, Bouwend nederland, MKB Infra, Infra Innovation Network, WOW (wegbeheerders ontmoeten wegbeheerders) and so on.
To exchange information R&D, communication and commercial employees play an important role.
They also have a platform (intranet) called a 'wegenbouw'-innovatieoverleg and 'Strukton Civiel innovatieoverleg' to share and inform their employees.
To persuade other members of their social system hard measuring data is often the most important aspect.

Time
The time it takes for an innovation to be fully implemented in their working processes in order to scale up depends on the type of innovation. A new asphalt mixture can be developed within a year but for example the SolaRoad started developing in 2010 and they are still in a pilot-phase.
The time it takes to adopt also depends on the innovation (incremental versus radical) and the willingness of agencies to adopt.

Social system
The R&D department, himself and the technical director often stimulate innovations to be applied in tenders. Other agencies and CEO's often determine if an innovation is applied or rejected in tenders.
Few people often have the authority to take these decisions.
Their organization is open minded but a lack of money (counts for the whole branch) and better risk management are problematic. Looking at 10-20 years ago there was much more collective money available for research and innovations (in the whole sector).

Innovation strategy:
One of their goals is to further implement OPA8 (type of asphalt), further develop SolaRoad and implement all kind of process innovations.
They hardly buy licenses of competitors or sell licenses.

Barriers to scale up product innovations:

- Reluctance and unawareness.
- No risk appetite.

Stimulants to scale up product innovations:

- Create more quality
- Win more projects (stable continuity)
- Being more cost-effective.
- MEAT, depending on the criteria. A contract with a maintain-part in it, works pretty good. However for the really big projects (DBFM), innovations can be too small (for example, an innovation of 1 million euro on a project of 120 million is only a small fraction and doesn't influence the outcome.
- Not only stimulate proven technology, but also invest in collective research & development and knowledge.
- The innovation agenda of RWS is partially helpful. Provinces and big cities are also very important (Amsterdam, Rotterdam, The Hague). They could give important incentives to scale up by working together. For example the IPG-program (Innovatieprogramma Geluid) to stimulate innovations on a broad scale. The innovation agenda of RWS only has themes, it should also require SMART goals and related actions.

E3 – Van Gelder

Respondent: *Klaas Neeteson*
Function and company*: Manager Strategy and Market – Van Gelder*
Interviewer: *Manu Klauwers*
Date: *25-07-2016*

Product innovations scaled up:
They were the first to apply recycled ZOAB, re-generated ZOAB. 8 years ago they had it validated, until now companies are able to do the same. It made it possible to use 50% recycled ZOAB in a new ZOAB mixture.

Developments with asphalt are an ongoing process in order to create a lower cost price. Often achieved by reducing the temperature or more recycling of old asphalt. So the innovation is focused on the cost price, unless you get the opportunity to apply an innovation in an MEAT application of a project where you can earn back most of the investment. An example was the road of the future where the MEAT was 24 million euro on a maximum price of 45 million. Visual renewal was 1 figure and related to 12 million euro. Most times 2 points difference between contractors in MEAT is the maximum. In this case it is related to a high amount of money. 2 points would give you 3 million euro cost advantage.

Noise reducing asphalt was slowly being accepted and implemented by RWS and contractors. But the disadvantage of the asphalt mix was that it was sensitive and it wasn't applicable for areas which had a high friction level. Especially intersections with traffic lights were not suitable but the client still wanted to reduce the noise so contractors had to become creative and come up with solutions.

Product innovations not scaled up:
Had had a tender from the province Noord Brabant and the municipality Oss for the road of the future N329. It is 6-7 km long and the MEAT-criteria was focused on visual innovation and a energy-neutral road. They won the contract together with Ballast Nedam. For example the lights which travels with the same speed of the car's allowed speed (80 km/h for example). Heijmans had glow in the dark lines in some km of road connected to theirs. The development project for the lightning was a rough cycle and was developed new in the road of the future. Those products are not scaled up at this moment.

Characteristics of an innovation:
Relative advantage:
- Low cost price (lower than the current standard) on the long term but also the short term.
- Sustainability because it is requested

Complexity:
Will mainly stay at their core competences. But in the asphalt business they often look with their partners what the possibilities are.

Compatibility/Trialability/Observability:
-

Communication channels:
Have a lot of partners for different products/innovations. Such as for roadsides solutions. Innovations are described on the intranet of their company but are also discussed in the monthly meetings.
Early supplier involvement from RWS to the market towards different topics/innovations or tenders is one way to communicate innovations.
Fairs are not really used for innovations. They only stand on fairs as a contractor for example in Hardenberg and next year at the InfraTech.

Time:
The tendering phase is often long enough to discuss certain topics.

Social system:
Their own infra department is very compact and they mostly can get an innovation through quite easily, but it also has to be done for their competitive advantage.
They focus on entrepreneurial skills of employees to cope with new products and innovations.
Learning is mostly done in a kind of training. Only the involved employees will be informed and trained.

Innovation strategy:
Often the client (RWS) steers towards the developments. It could be that they want a percentage of recycled material in the road. Within one year every contractor is on the same level. They have to because otherwise their company could not compete and win tenders. In general they don't have a strategy.
During market consultation subjects can be discussed and adjustments can be made by RWS in tenders. Dialogues should stimulate the discussion between the client and the contractor. There are good and bad experiences. You have contracting teams of RWS who keep all the options (ideas) to themselves, afraid they will say too much. Or disrupt the level playing field by explaining subjects to one contractor instead of to all.

Barriers to scale up product innovations:
- MEAT-criteria which doesn't make a distinction between solutions of contractors. The award criteria is minimal.
- Uncertain return on investment due to unknown market opportunities to apply/sell the innovations. RWS could communicate more with provinces and municipalities in order to increase market opportunities. For provinces and municipalities suppliers can also integrate an innovation in a RAW specification.
- Predetermined requirements
- Regulations and legislations
- You can't submit alternative solutions for a tender.
- If you look at roadside systems and the in-car technology you see that these developments are more related to the companies in the automotive industry. Not really at the contractors.
  Contractors are participating and following these companies but they are originally constructers.
- Financial risks are limited but the tendering costs are very high. Tendering costs are between 0,8 - 1,0% of the contracting sum. Where the compensation is mostly 25-33% which for large projects such as 100 million euro will cost a company several tons without having the certainty to win the contract.
  For projects above 500 million euro there are only 2 combinations left that are willing and able to realize the project.

Stimulants to scale up product innovations:
- MEAT-criteria which make a difference between contractors.
- Future prospects which include a clear market to apply innovations.
- Being able to submit alternative solutions for a tender.
- DBFM contracts instead of D&C or RAW. It especially stimulated the focus on the total life cycle of products.
- Accelerated validation process.

E4 – Ballast Nedam

Respondent: *Jan Niks*
Function and company: *Division director – Ballast Infra (Ballast Nedam).*
Interviewer*: Manu Klauwers*
Date*: 11-07-2016*

Product innovations scaled up:
Asphalt (mixtures).

Product innovations not scaled up:
Road of the future, LED-lightning, and solar panels (successful implemented, but isn't used in other projects).

Characteristics of an innovation:
Relative advantage:
- Sustainability
- Cost advantage

Compatibility:
If an innovation is applied in a project with success according to the client (RWS), it will give the contractor a client satisfaction declaration. Therefore it is approved and even if a project manager never heard or used the innovation before it should be sufficient to consider it as a proven technology and look at the possibilities to apply it in another project.

Complexity:
Doesn't really occur in their company. A lot of things also went wrong for example in tunnel systems which caused some reticence of RWS as well as the market to apply innovations. The national tunnel standard is still guiding. They did 15 years to come towards such a standard, but how fast does RWS adjust the standard in order for (proven) innovations to be applied.

Trialability / Observability:
-

Communication channels:
They communicate with partners and manufacturers. Once in the two years new developments internally and externally are showed and explained in an innovation day.
The innovation platform on the intranet shows current developments and applied innovations which is visible for all employees. The administrator working at the project and tender support department is responsible to communicate the knowledge internally. Project evaluations are also communicated but to a lesser extent.

Time:
Looking at the innovation culture, there is a certain amount of time and money available supported by the management. In general the people are becoming more and more open for innovation.

Social system:
The design department develops products and also focuses on innovations.
Furthermore they have some partners with their own profession such as foundation engineering, specialized earthwork, guard- and crash rail, et cetera. Those companies especially look at how they can optimize the process, less on materials. Innovation lies in the portfolio of the CEO. He has the responsibility to do something with it.

Innovation strategy:
Mostly focused on process innovations instead of product innovations. Not a real strategy but the focus lies more towards asphalt, choice of materials, layering structure, et cetera. These are things that you want to keep for yourself. It should be related to the core business and the development costs should be earned back within one project.
Licences are not really sold in the road construction sector. An example which did sell was their concept called XBOX. You pay a fee to use it from BAM, but in this case you always will lag behind in costs compared to BAM. But in essence they are also not willing to use and promote an innovation (concept) from a competitor.
Would then prefer to design something that comes close to the concept in order to compete.
Few innovations were developed and applied due to lack of money in the past. Innovations that were applied were especially in projects which they won. Which is another way then putting some smart persons together to develop innovations.

Barriers to scale up product innovations:

- If you apply an innovation in a project it is very difficult to keep it to yourself. Other contractors will adjust your innovation slightly and they will have a similar product. It is one of the reasons contractors are not very innovative.
- Regulations which are not adjusted in other tenders could be a barrier.
  Often innovations haven't proved itself for a longer period of time which is important when looking at the promised lifetime or the request lifetime by RWS.
- Most times there is no space for an innovation such as when it has a shorter lifetime. This is also due to the fact that RWS wants to give an equal chance for all market participants in a tender. If one company doesn't have the innovation they could exclude them to participate.
- In the evaluation there should be more appreciation towards innovations. But it is difficult for RWS to know which innovations are available and what evaluation criteria should be described.
- The requirements shouldn't be prescribed on forehand. In one way RWS knows what they will get but you will exclude and de-motivate contractors to apply new innovations.
- In the infrastructure decree the ministry of Infrastructure and Environment have more opportunities to stimulate innovations than RWS. Especially in the specifications and the MEAT.
- When a tender is more focused on price and MEAT doesn't change it.
- If RWS doesn't like the innovation that was developed it is demotivating and it would stimulate using more standard products which are proven and especially are cheaper.

Stimulants to scale up product innovations:

- When MEAT is focused more on quality and other competitive advantages besides costs contractors will invest more energy in new innovations.
- Give space for ideas and innovations of contractors instead of prescribing most restrictions in the tender.
- Increase the percentages of MEAT. It differs enormously between projects. In one project it could be 10% and in another it could be 60%. When it is 60% it is more interesting since you can have a greater advantage with a higher cost price.
- A more flexible lifetime could be helpful which can be one of several points that a contractor can achieve via innovative products but which is then stimulated by a premium.
- If RWS communicates what requirements they will adjust in order for innovations able to be applied and what evaluation criteria (and/or MEAT-criteria) tenders will have to achieve the most desired outcome.

E5 – KWS Infra

***Respondent**: Rinus Kok*
***Function and company**: Business Developer - KWS infra (part of Volker Wessels)*
***Interviewer**: Manu Klauwers*
***Date**: 12-7-2016*

Product innovations scaled up:
Mostly asphalt mixtures which were developed with the market in a general way.
Recycling started in '83/'84 with a couple of MKB companies. RWS was satisfied and they said everybody could apply asphalt which is partly from recycled asphalt. But everybody first needed to do a pilot project. Within 1,5 years every contractor had done a test in a pilot. Afterwards the market parties came up with a parallel manufacturing process which allowed them to use 50% recycled asphalt.

Product innovations not scaled up:
Prefab ultra-high strength concrete panels (part of the old Brienoord bridge). Everybody thought it was nice, concerns were if it was economically achievable. And the main concern from RWS was that KWS was the only producer of these prefab plates, and therefore KWS would have an advantage in other projects.
But most of the times you probably have half a year leap compared to your competitors.

"Zonneweg" is from 2001. They already applied 1000s of metres. It is based upon a lower layer of asphalt where an open layer is placed on top and then finished with a closed layer. No pipes or wires, the water is collected on the higher part and then flows back towards the lower parts. It is one of the innovations which was asked at RWS why it wasn't applied. To create energy from the road is one thing but they also need to have consumers. During a tendering phase you don't know if you win the contract so you can't make binding agreements with potential buyers. So you don't have a position to arrange such things.

Conway city is a unique asphalt type. Normally noise is being avoided when it comes in hollow spaces. The Conway city has a conclave structure with capped stones. Since a couple of months they also have proof that the rolling resistance is lower and therefore a fuel reduction for road users of 3-4%. If you then capitalise the figure on the total lifetime of the road you have a significant advantage. Started in the city. First tested and implemented at 50km/h roads. Next step is 80 and then national highways. At this moment RWS doesn't provide the space, but it first needs testing.

First step to implement and test an innovations is not the biggest problem, you are often able to place it somewhere in a pilot. But then the next step becomes difficult when they start talking about guarantees. Where normal lifetime is 5 years they want a lifetime of 15 years. And only if it is reasonable they will go along. Question is if RWS wants to get new innovations and think together with the market or not.

Characteristics of an innovation:
Most innovations are an improvement of existing products and have a cost advantage.

Relative advantage:
- Sustainability is important, but it is not equally important in every project. Nevertheless sustainability will stay in our society and therefore will have an important role. But how to describe and measure it?
- Cost advantage.

Complexity:
Complexity could be an issue. Plastic roads for example is a total new product, the management was first a bit sceptical but they had a lot of reactions so they made some money free. But the material plastic was totally new, the characteristics and the design of it was something challenging. They decided to look for partners. They now have 1 partner that has a lot of knowledge in plastic recycling and plastic materials and another partner was very good in the design of plastic. But it is difficult when you don't have the resources or knowledge.

Trialability:
It often starts with a small scale pilot. Which is visible and at that moment will be analysed. Next time it is executed in a larger project which makes it more and more visible.

Compatibility / Observability:
-

Communication channels:
It is important to trust certain people. Some persons you can talk for hours in order to be convinced or who have you convinced about their product.
It often takes a lot of time to talk one on one with RWS whereas you want a whole lot of people to know about your innovation.
If an innovation is feasible and there is sufficient information than RWS and provinces will be informed as soon as possible. Not directly related to a project.
Internet is also an important source to look for innovations worldwide. But they also receive mails via partners or other companies from time to time about innovations. Then they need to make choices which innovation to look into. When they have an innovation it will be put on intranet. But the employees need to read it themselves.
Once a year there is an innovation day for all Volker Wessels companies. But only the managers are present, and they should communicate it through the rest of the organization. But managers often forget the innovations when you ask about them a couple of months later.

Time:
It depends on the person and the type of innovation how long it takes before employees accept an innovation and before it is implemented. Also related to the needs of RWS.

Social system:
Collaboration with different members of the construction industry. For example they collaborated with the University of Twente where they developed the Aspari, a process innovation. They are helpful in joint problem solving.
At their own company there are few young people, especially with some meetings where you want to talk about innovations there is a lack of young talent with new ideas. You should have persons that are willing to take effort in order to get new innovations.
Key persons have different sides. You have the production and the contract side. A heavy weight can make a difference if he is capable and willing to implement an innovation.
The unit business development often initiates the innovations and seeks persons that are willing to investigate and implement it.

Innovation strategy:
Previously they applied product- and process innovations which were very close to their core businesses. Since this year there is more structure, they have had some meetings with all the branch managers to create a clear innovation strategy. How they will arrange it is still unclear at this moment. An important note is that they are very dependent from the sales (of RWS, provinces, municipalities) and so how many they could potentially earn with it which is now very uncertain.
In essence they are thinking very broad but maybe they have to look even bigger just like the plastic road in order to be really innovative. Or just focus on some techniques in other markets to apply. For example by looking at the dairy industry who also mix, heat, dry et cetera just like an asphalt process.
The unit business development is the initiator and the decentralized branches throughout the Netherlands should bring it to the next level and should be willing to implement it in a project.

Barriers to scale up product innovations:
- Hard to find the right persons at RWS to create or apply innovations. For the technique there are only a few people left which are familiar within the branch. But then you also need to go to contract managers et cetera. But with total new innovations you don't know who to talk to in order to get a follow up of your product at RWS.
- You need to put a fight several times in order to scale up a product with different persons in different projects. You need to go through the same loop several times again which is quite strange.
- Within contracts there is little space to change, or it is a change in the specifications ("bestekswijziging").
- RWS went from a technical organization towards a management organization which leads towards other agreements in contracts. And the question is if there is enough space to innovate at this moment.
- Internally for very large projects like SAAone they also don't want to get too much risk by applying innovations due to the very high fines in the contract. You have the possibility but then these fines are holding them back again.
- The time between the application of a tender and the tender itself is very short. Companies will rely on existing and well-known technologies. For large tenders like the Zuidasdok there is enough time (like a year or so) but the smaller tenders only have 3 months.
- Also smaller works of RWS around 15-20 million euro can have a tender phase of 2 months. Sometimes it frustrates what an amount of tendering costs are made for nothing. Especially when you lose a tender it will cost you money which will also pressure developments of innovations.

- Also an internal problem is whether or not KWS wants to put their idea on the table, during a market consultation or a dialogue session. Mostly 2 or 3 dialogue rounds will be held which is limited. But it can be very hard when a request of a tender is very guiding. It limits the possibility to apply an innovation.
- Companies currently will keep all the knowledge of innovation to themselves and don't want their competitors to learn. KWS also has patents on some products but the market should learn and share more from each other.
- The reliability of RWS is difficult. One day they tell you something and the other day they will change their statement. A contractor doesn't invest millions in something where he doesn't know for sure it can be applied for at least 10 years in the market.

Stimulants to scale up product innovations:

- A contractor is best in the design and manufacturing of a solution. But a lot of agreements are already made in the trace/request. This limits the innovativeness of companies.
- Clear MEAT-criteria and how it is measured, DUBOCALC was a good initiative. It should not be possible that if you can "write" down the sustainability in a project "better" that you will receive higher scores. It should be measured in an equal way. You can check what works and set up a standard together with all contractors to do so. Choose some standards and give space to some points where each contractor can be distinctive. For example the amount of recycled asphalt.
- When RWS takes a lead in the developments of some topics / goals.
  For example the 2-layer ZOAB project (Zebraproject) where 8 contractors were invited. Several pilots were provided in order to test, measure and to compare the different materials. The market learned from each other and RWS learned a lot more of the whole market and their products.
  A program such as the HWBP can be a good initiative to increase innovation.
- Contracts should be made more flexible if you want to be able to implement new combinations of techniques such as concrete and plastic.
- In France, a contractor needed to spend 0.5% on innovations which wasn't been used before in other projects. Specifications were relatively wide but it had a fixed budget that needed to be spend.
  It could steer up the market, but RWS should look carefully at the risks involved.
  Focus on innovation in a projects such as InnoA58. It stimulates innovation but it should not always be an obligation to apply innovations if it isn't necessary. But it is often the question how RWS is going to put it in the tender.
- RWS could give neutral companies such as CROW the task to play the facilitating role to develop innovations in for example sustainability and to create and share knowledge. In earlier days CROW had work groups to develop new technologies. It was sponsored by RWS with 600,000 euros.
  TNO also does a lot of interesting research where most companies are not aware of.
- A collaboration between RWS, provinces and municipalities could make a statement what innovations they need or what goals needs to be fulfilled. When the potential sales volumes will increase it will stimulate the investments of contractors whereas it will be more beneficial and the return on investment will be much shorter making the business model more attractive. RWS could discuss more with municipalities in for example the IPO (Integraal Provinciaal Overleg).
- RWS should describe clearly what they want and then discuss it with the market. Innovations are now seen as risks. First discuss the needs, then the risks with the market so you can work together and RWS could give space in a tender when contractors have proposals / innovations to apply.

E6 – Dura Vermeer

Respondent: *Anton Jansen*
Function and company: *Cost expert (tenders) - Dura Vermeer*
Interviewer: *Manu Klauwers*
Date*: 8-7-2016*

Product innovations scaled up:
EME (type of asphalt, under layer).
Noise-reducing asphalt (for specific types of speed limits, 50 or 80 km/h)

Product innovations not scaled up:
Self-cleaning bank, so you don't really need to place sewers for example.
Jointless connection between the road and a bridge.

Characteristics of an innovation:
Relative advantage:

- Cost advantage (also if it is more expensive than it contributes to MEAT)
- Energy usage
- Carbon dioxide reduction
- Recyclable
- Risk level

Compatibility:
A lot of products are often custom-made, for example traffic management systems. But you always have to look at the goal, the lifetime it should have, the minimum requirements et cetera.

Complexity:
The complexity of a product can be important whereas different employees in an organization are not keen on changes but other people are open for it.

Trialability:
It is important when an innovation is not yet tested or validated, if it is tested than it is of less importance.

Observability:
Depends on the characteristics of individuals. One person may be open for innovation and is willing to try it and another person first wants to see and know how everything works. And these different types of people are needed to make a good collective decision.

Communication channels:
Internally the innovation manager and engineers have contact about innovations. The innovation manager looks actively for innovations online but also with partners and supplier.
They also have suppliers of innovations coming to them or they develop the innovation together with their partners.

Time:
It often takes a lot of time before a product innovation can be scaled up and also before every employee could cope with it.

Social system:
End responsibility to apply an innovation lies within the management. In an earlier stage of the innovation process the people at the working levels look at an innovation to see if it is applicable and workable.
The innovation manager looks widely in the market what he/she can apply.
The engineers prefer to stay in their comfort zone but the challenge is to talk to different people and to motivate and enthuse them. But there is often one leading person to do so and if people are interested the innovation needs to be analysed thoroughly. For example expansion joints are not always applicable and are also determined by the requested lifetime. This also differs for D&C or DBFM contracts what is requested and if it could be applied.
The drive to innovate should lie with the individuals to challenge themselves and to develop new product/ideas.
Often an innovation is developed by two parties. It is not only steered by Dura Vermeer or only offered by suppliers.
Especially within the maintenance world, they have a good collaboration with a partner. They are not the cheapest but are really innovative and think a lot about how to use machines and processes in a more effective and efficient way. Therefore a contractor and sub-contractor often develop innovations together.

Dura Vermeer also challenges suppliers to come up with innovative solutions for a problem.

Innovation strategy:
From the management team innovation is stimulated. So there is time and especially budget for innovation. Ideas should therefore be communicated with upper layers of the organizations so it can land, instead of the lower layers where it could be buried and never be applied. People should work together to understand the possibilities and the restrictions and see the chances for implementation or to stop developing.
They don't have a specific innovation strategy within the company. Especially developments on asphalt. And the company looks at their competitors in order to keep up and also develop new products that will match or outrun them.
They are continually comparing their own advantages to those of their competitors. Nevertheless the duration of these advantages of an innovation often will take place once or twice within a project before your competitors will develop something similar or buy it in order to do the same.
Selling your own products towards competitors is not very common. In the concrete world it is more common. It doesn't matter if you buy the same type of concrete at supplier A or B. In the asphalt sector Heijmans, BAM and Dura Vermeer used to work together in a asphalt production plant to reduce costs which was not approved later on due to a lack of competition, the NMA (Nederlandse Mededingings Authoriteit) saw it as a sort of cartel.
In the beginning when low noise reduction asphalt was developed by Dura Vermeer there were only a few suppliers. But it took some time for the product to be implemented on a broad scale.
The Ooms joint is a very good product but is very expensive. Looking at SAAone KWS applies this joint on a small scale since it costs around 4000 euro per m2. But on the other side you don't have maintenance costs during 25 years so you only need to replace the top layer of the road.

Barriers to scale up a product innovations:

- The amount of risks related to an innovation could be a barrier.
- There is not always space and permission to test or apply product innovations during the realisation stage.
- Furthermore most people avoid innovations if they are not yet "proven" technologies. It depends when someone calls it proven. It is not always clear after an innovation is applied such as the noise reducing asphalt what the exact lifetime of the product is.
- Sustainability was very popular for some years, especially in the MEAT-criteria. Nowadays these are checkmarks which almost every large contractor can comply to, for example the CO2 ladder level 5. Another MEAT-criteria is the "vehicle hours lost" (in Dutch: voertuigverliesuren) which at some point could be achieved by every contractor. So if the MEAT doesn't differentiate products of competitors it won't stimulate them to apply product innovations if they are not rewarded for it.
- The measurement of MEAT-criteria for example isn't always clear and makes it sometimes unable for RWS to compare the contractors. For example The CO2 output where asphalt recipes and manufacturing processes differ between contractors, sub-contractors and suppliers.

Stimulants to scale up product innovations:

- MEAT can be a stimulant when it gives a significant reward related to the standards that are used. Since it should always generate money for the company. The MEAT components should have an advantage whereas in the project A6 the MEAT-components were relatively small. Therefore it was mostly determined on price.
  The A27/A1 which Dura Vermeer lost. The maximum price was 200 million euro and a MEAT valuation of 130 million if you score a 10 on every component. Then it is very interesting to look at for example sustainability. You will spend extra time and money but in the end you can earn it back by the fictive MEAT-price. This system will make that an MEAT-score on a component which is an 8 will not be sufficient anymore but will need to be a 9 or a 10.
- MEAT-criteria should be formulated separately for every project. In general the higher the MEAT-criteria the higher the quality of the work will be that is delivered. In this way you can apply product innovations, which mostly have higher costs.
- RWS can push innovations to be applied such as in the road of the future in Oss. Need to be clear about what they expect and want to do with it.

E7 – Heijmans

Respondent: *Kristel van Haaren*
Function and company*: Head Sales & Business Development - Heijmans*
Interviewer*: Manu Klauwers*
Date*: 28-7-2016*

Product innovations scaled up:
ZOAB was a development by Heijmans but after applying it in a tender RWS became the owner and could make every contractor to develop/produce it without Heijmans receiving any money for it.
Another product is the recycling of ZOAB which is something that was tested and applied together with RWS.

Product innovations not scaled up:
Glowing lines is not scaled up due to some problems with the product itself. But now Heijmans developed it a step further which they will be testing soon. It will interact with the car so you don't need information panels, it will signal and communicate with the user decreasing the need for sensors in the road or car.

Characteristics of an innovation:
Relative advantage:

- The life cycle of the product is very important. You can't develop an innovation only for 1 project. It was one of the issues in the building sector where they did develop an innovation for only one project.
- The cost price is always important.

Compatibility / Complexity / Trialability / Observability:
-

Communication channels:
Communication is often done via marketing on the outside via different channels and spread internally. Nothing is as fun as someone who says how nice you are instead of you telling someone else you are nice. More storytelling by their clients or other stakeholders of a project.

Time:
Can be years depending on the type of product. A product is proven at Heijmans when it has been applied 3 times successfully in a project, it can then be commercialized.
From 5 months till a year or even 5 years. Asphalt could take 1 year but also 5 years.
It could take time because of the technological developments or because the market is not ready yet.

Social system:
They also have product managers, who have a product which they want to implement in a project. They sell their products to RWS but also some types of asphalt towards the BAM or KWS. But they also sell licenses to Fulton Hogan (New Zealand) which is also part of their business model. They will train them and give the required information about the product and in return Heijmans receives an amount of money per km road that was realised.
Another important part of their social system lies with partners they work with such as BMW, TomTom, TNO, et cetera. They normally don't develop the technologies with RWS but they do validate the product in conversations with employees of RWS to see how they look at some problems and solutions.
The final decision if an innovation will be further developed depends on sponsors and implementation partners.
The project leader will pull the innovation and the product manager will set the price and do the marketing.
They have different focus groups and employees to cope with developments and to apply innovations. In the idea stage of the innovation development funnel the product manager has an important role but they also have product developers, a project leader innovation and business developers (who choose partners) to discuss opportunities.

Innovation strategy:
Heijmans find themselves very different than other contractors. It is a strategic movement, in earlier days they were focused on what RWS wanted and they would develop it. But nowadays they have a couple of strategic focus points in materials & energy and technology & systems. For example they focus on smart mobility but also on smart materials, recycling and other environmental aspects.
Around these topics they develop products which is done by their Research & Development department.
They follow a (innovation) funnel, the stage-gate principle. From idea, feasibility, pilot, implementation and commercialization.
They focus on different types of business such as RWS, Schiphol, and so on. And they also have their so called "specialists", who are focused on different domains such as technology & systems, road engineering (marking), asphalt, et cetera. They deliver the knowledge, design and so forth for different projects.

Product innovations will become part of (some of) the specialists. The specialists sell the innovations in the projects but could also sell it to the BAM.
The department CMO (commercial, marketing and development) works together with several persons to see which trends the market shows, what marketing needs to be done, et cetera.
The business developers look at partners who can produce their idea. Therefore it's business model is very different than other products.
Besides product development Heijmans has product management, where the link to the business is made.
Heijmans spends 2-4 million euro on innovation which is quite a lot if you look at other contractors.
Since RWS can't provide pilots towards some innovations Heijmans made a choice not to test and develop some innovations with (or for) RWS. Only in a later stage.

Barriers to scale up product innovations:

- Not involving the contracting department enough during the developments and testing stages of a product innovation. A lot of innovations were stimulated by a program or contest. An innovation was chosen but the contracting department was never involved upfront in the contest so it couldn't be applied in a project.
- Too many risks for the contractor decreasing the willingness to implement innovations.
- Also when RWS wants to be the owner of the patent of a product it is seen as a barrier to scale up. For example Heijmans didn't apply in a contest for low amount of noise since RWS wanted to have the patent.
- The demands of RWS changes very often so you don't have the certainty that your product is going to be sold to RWS.
- A lack of communication from both sides to discuss and solve problems related to innovations. Such as to change parts of a contract.

Stimulants to scale up product innovations:

- If RWS took a greater part of the risks it would stimulate contractors to implement more innovations, especially for radical innovations.
- MEAT-criteria (but RWS should let the market buy products from each other and should accept that one contractor innovates more than another). For example one innovates on bio-based products and the other contractor more on lightning. Contractors will get different profiles which creates a healthy market such as the industry in the Netherlands.
- RWS should have the guts for long-term contracts to ask innovations for several years. Brabant asked the market to provide innovations for 15 years in a contract. But you should be able to show that you are able to do so internally.
- It could stimulate if RWS takes into account if a contractor has a good ISO qualification around their innovation processes (development). It is still too easy for some contractors to sit and ride along buying products from other contractors. Which is not a problem when talking about matured products but it is for products in earlier stages of their lifecycle.
- Require a percentage of the products in a project to be patented.
- Clearly ask an innovation out in a project.
- A program could be helpful if it makes a clear view on what they demand and what the goals are.
- RWS should work together with more companies. For example insurance companies are also willing for some innovations to be developed if they decrease the amount of accidents. They could even be willing to pay money for it. It could stimulate product innovations to be applied by contractors.

E8 – Volker Wessels

***Respondent**: Rob Jaeger*
***Function and company**: Program Manager – Volker Infra (Volker Wessels)*
***Interviewer:** Manu Klauwers*
***Date**: 26-7-2016*

The data of Rob Jaeger was excluded from the interview where it was clear that KWS Infra is the executive company for the GWW for Volker Wessels and the managing director believed in a strongly decentralized structure where all daughter companies should run most activities on their own without steering from a corporate level towards i.e. innovation. Therefore only the data of KWS is used since an overlap of these two could make a wrong impression about the data since there are only 10 contractors interviewed.

E9 – BESIX

***Respondent**: Alexander Heeren*
***Function and company**: Commercial Director Infra - BESIX*
***Interviewer:** Manu Klauwers*
***Date:** 19-7-2016*

Note: due to a lack of time and a delay information was limited.

Product innovations scaled up:
Mostly types of asphalt or concrete.

Product innovations not scaled up:
Most examples were focused on process innovations or product innovations in water project such as the Beatrixsluis.

Characteristics of an innovation:
Relative advantage:
- Sustainability
- Low costs

Compatibility / Complexity / Trialability / Observability:
-

Communication channels:
They work with a lot of partners and companies. But also with universities, especially in Belgium.

Time:
Can take long but depends on the product. There isn't really an innovation culture. Some people are open minded and innovative others are not.

Social system:
They often work together with Dura Vermeer or with Mourik due to long relationships.
In earlier days they also worked with Rasenberg but it was taken over by Strukton which made them change their businesses.
Close contacts are held with Brussel, Leuven, and Gent Universities.
Bouwcampus (Bouwend Nederland and RWS are a member), where Bouwcampus and RWS talk to each other about what the members want (experts on concrete, asphalt, et cetera) and RWS.

Innovation strategy:
They don't really have a strategy for product innovations in the road construction projects. But in the organization there is a group of persons in Brussels (headquarter) looking organization wide how to implement innovations in their working processes.
1. Innovations on group level. Drones that do maintenance in a tunnel.
2. Innovations in activities such as how piping in a dike could be prevented.
3. Geographical, differences between countries in legislations and regulations.
4. Start-ups, to see if they can work together.

More focused on innovations such as virtual reality for the maintenance and/or to communicate directly with others who are watching with you.
In the board meeting they have 12 projects that can be approved. So they want to adjust and apply an innovation which is also competitive in future projects.
They often develop innovations with partners. It should involve a team where each person is equivalent to each other.

Barriers to scale up product innovations:
- High tender costs, no full compensation for these costs and no certainty you will win the contract.
- Requirements and specifications hinder the application of innovations
- RWS is asking tenders in such a way some companies complain they won't have a business anymore because of them.
- People of RWS (or the market) who stick to old habits and knowledge. Doesn't specify a typical function of a person. Could also be a lawyer that wants proof until it can be used and current standards are changed.

- Dialogues towards a tender often lead to no changes in the tender itself and innovations couldn't be applied.

Stimulants to scale up product innovations:

- Functional specifications (In DBFM contracts it occurs more often). The disadvantage of a technician is that he has everything in his head and he wants to describe it in the tender. So changing it will be very difficult.
- MEAT-score. What is important is how distinctive the points in the MEAT are compared to each competitor. For example the A6 has quite a dispersion in euro's. But the dispersion between the contractors was minimal.
- RWS should describe clearly what they want in the future, such as for example Melanie Schultz who said that in 2020 all floodgates should be energy neutral. In this way companies are anticipating what they could do in energy generation, hiring people, doing investments, getting different suppliers, et cetera. RWS could do the same and talk to the market to see how and if it could be done.

E10 – BAM

***Respondent**: Ad van 't Zelfde*
***Function and company**: Business Developer - BAM Infra*
***Interviewer**: Manu Klauwers*
***Date**: 12-7-2016*

Innovations scaled up:
ZOAB (asphalt) is one of the innovations (technologies) which was a development set up by RWS that was scaled up. For asphalt the large contractors, who mostly have their own production plant(s), have the whole supply chain in their control. The concrete suppliers on the other hand are dependent on the whole industry.

Innovations not scaled up:
Silent road is a development RWS wants. But the question is if there is a market for it. BAM for example doesn't know how large it is and if it really will get there. RWS started programs and tests but you can also change legislations, so how stable is the sales perspective.

BAM had a solution to drill a small hole in the road to be able to see how long the road will last. But it was not bought by RWS because they were the only supplier of such a product. Therefore it wasn't scaled up.

Way in motion is a product which registers the weight from vehicles without hindering the traffic. It didn't scale up because RWS doesn't have a clear view of what to do and how to connect all the information (data).

Characteristics of an innovation:
Relative advantage:
- Costs
- TCO and LCC
- Environmental aspects such as CO2

Complexity:
Doesn't have any problem to cope with innovations that lie outside of their core competences. But it also depends on how much of an investment you need to do in order to successfully develop and implement it. Sometimes a reason to do so could be for the PR. Currently they are focusing more on their core competences.

Observability:
The development time takes years so therefore they are reserved in showing their innovations but once it is successfully implemented people are proud and want to show everybody to convince them of the benefits of their product.

Compatibility / Trialability:
-

Communication channels:
Talk to different companies and partners to exchange information and knowledge.
In the past there were innovations days, but nowadays they doesn't do these days anymore due to cut downs. Nevertheless they expect it to come back in the near future.

Time:
It could take 10 years before the goals mentioned on a higher level, such as sustainability, take form in the tender due to the procurement department. So innovations could stay on the shelf for years until it could be applied in actual projects.

Social system:
Internally they held contests to think of new ideas where some ideas would then be developed. Often it was hard to test the product in a pilot where you don't have the space for it. Internally people are often focused on the process so are not very willing to implement it. Project managers should also be willing to apply it and give space in some kind of testing area.
You always have some people who want to buy something, then you have technicians who say that the product is not yet tested, the contract manager says it doesn't comply to several legislations another person doesn't think there is enough market for the investment costs. Some persons doesn't believe in the product. All people have their own profession and opinion.
Often there is a lack of time to talk about how a contractor means something. It is shut down before they could explain what they meant.

The branch organization can steer and focus on innovations / developments. But they also have the issue that one organization develops fast and the other very slowly or isn't developing some types of innovations. But they have to serve everybody so it is difficult.
But they are very important on the general questions about regulations and legislations for example.
Most companies doesn't have the guts to say the things what went wrong in projects of RWS. They are afraid of the consequences.
The department technique and development are keeping up with the knowledge and experience of innovations and they also have a lab to test and validate product innovations.

Innovation strategy:
Only a few road construction companies are present in the coming years and replacement and extension of current road constructions will be the majority of the projects. Therefore horizontal recycling is becoming a focus point for innovations. But also sustainability and a circular road are becoming more important.
On the short term innovations from the past are slowly becoming implemented. Such as CO2 reduction.
It took time to become familiar within the organisation but also to be able to implement in the projects at RWS took time. You don't develop an innovation for one project such as CO2 reduction since it takes too much development and time related to it.
Innovations are related to unique problems from projects such as a foundation of a large wind turbine on sea which is not fixed. They could also be related to a product which needs to be cheaper or more sustainable.
But innovations are also forwarded by small- and medium sized companies in the market.
You see that developing 2 things at the same time is hard and time consuming. Therefore the focus lies on developing 1 innovation on a high level within the company.

Barriers to scale up product innovations:
- The government wanted to stimulate e.g. sustainability but the procurement side doesn't show these ambitions in the project tenders.
- RWS sometimes holds down an innovation for implementing it in a project because of the fact that the company is the only one that can deliver such a product. It even happened once that a contract explicitly forbid a product to be offered in a tender.
- There is little money available to invest due to the former crisis in the building environment.
- Communication with RWS is very slow. They wanted to put forward the "way in motion", providing and connecting data of the road with the cars. BAM asked RWS to talk to someone what RWS's value is towards data. He is waiting 2 years and never talked to someone.
- Functional specification is good but it should not still be disadvantageous for innovations when technical specifications are hidden somewhere. Project Managers and Technical Managers are not always aware of it.
- The "duurzaamheidsladder" level 5 is not a unique factor anymore. It should almost be a standard requirement but not part of the MEAT since it is not distinctive.

Stimulants to scale up product innovations:
- Clear goals from RWS such as the desired life time of a product in the future, the sustainability outlook (operationalized), but also the potential sale volumes in projects.
- Give a clear view when they want goals to happen such as a % that needs to be recycled of the total km of road or the amount of CO2 that needs to be reduced. But they need to described the steps, including offering test locations, facilitating pilots and name future projects.
- Internally low integral costs.
- Clear view of what to be expected in 5 years and how it is being asked in projects.
- MEAT can stimulate innovations.
- Challenging the market.
- Functional specification
- Facilitate focus areas for open innovation. Often is a company has a great innovative product and are the only one that can offer it RWS is not willing (able) to buy it.
  The other way around when BAM was staying behind in developments compared to competitors RWS asked them to design a similar technology to those of the competitor that was leading.
  The market is influenced in this way. So RWS wants everybody to be able to deliver the same, which ultimately leads to competing in price which is something companies want to avoid.
- You could say I want 10% of the products that are applied should be patented. So these products are sort of unique and can make a difference. But it still bumps against RWS if you have a patent because in some cases you have a monopoly on that product. But it is not illegal, since you can always use the old product and win a contract on other (process)innovations. Patents can also be sold to competitors which is normal in a market such as Samsung and Apple.

Appendix F – Stimulants and barriers from the contractors

Stimulants and barriers, acquired from the interviews with the contractors, are described in the table below for each antecedent formulated in the theoretical framework in chapter 3.5. Additionally a "yes" was added if in the theoretical framework stimulants (St) and/or barriers (Ba) were mentioned for an antecedent.

Antecedents	St	Ba	Stimulants	Barriers
Environmental level				
Environmental pressure and policy	Yes	Yes	If RWS challenges the market for new product innovations.	
Regulations and legislations	Yes	Yes	If agreements are not already made in the trace/request of a tender. It can give space for the contractor to design a (innovative) solution. When contracts are made more flexible and adjusted if necessary to implement product innovations.	Can't comply to the reference requirements of RWS projects. Regulations and legislations are often not adjusted in other projects and therefore prevent product innovations to be applied again. If regulations and legislations aren't changed in other projects it de-motivates contractors to adopt and apply new innovations. Often innovations have to be proven itself for a longer period of time which is often not the case and therefore prevent upscaling to occur.
Requirements and wishes (demand)	Yes	Yes	RWS should be clear about innovations that are tested or applied for the first time what the market potential would be and where in future projects it could be applied. A clear roadmap should be described. For example the innovations applied in the road of the future N329 in Oss. Clear goals and demands should be formulated such as the desired life time or the % of recycled material. But also when they expect it and for which projects. If a contractor should construct an energy-neutral road what do they expect from contractors. It should	No clear market opportunities for product innovations in future projects. RWS is not really reliable as of what they want. So there is no certainty that your product is being sold. A contractor doesn't want to invest millions in something where he doesn't know for sure if it can be applied.

			be discussed within the market. RWS should have the guts to ask for innovations on a long-term. Brabant for example asked the market to provide innovations for 15 years in a contract. A clear vision from not only RWS but also from provinces and municipalities towards innovations. A lot of roads are blended into each other.	
Inter-organizational relationships	Yes			
Compatibility of organizations adopting the same innovation	Yes			
Fragmentation of the industry and professional bodies		Yes		
Collaboration between contractors and engineering- and consultancy firms		Yes		
Coordination and integration of companies in the market		Yes	RWS should facilitate areas for open innovation and push contractors to develop certain types of innovations. RWS should let the market buy products from each other and should accept that one contractor innovates more or is the only supplier. That is how healthy markets work. RWS could set up a program where innovations could be developed and applied. It should describe clearly what they want and what the goals of the program are. RWS can work together with more companies besides the contractors such as insurance companies who want to decrease accidents and even want to invest in innovations.	Contractors often don't know if product innovations applied at RWS can be applied at municipalities or provinces and vice versa. RWS wanted to stimulate e.g. sustainability in the market but the procurement side didn't show these ambitions in the project tenders.

			If RWS takes the lead in the development of certain topics/goals. The market can learn from each other and RWS can learn more from the whole market and their products. RWS should give neutral companies such as CROW the task to play the facilitating role to develop for example sustainable product innovations and to create and share knowledge. If RWS collaborated more with provinces and municipalities they could provide the market with more selling potential and thus upscaling opportunities. A clear goal on what product innovations should be developed is requested knowing it can be applied in future projects for several clients. IPO, "Integraal Provinciaal Overleg", could for example be helpful.	
Traditional channels of political communication		Yes		
Financial aspects	Yes			
Amount of competition	Yes	Yes		Although for projects of GPO the competition is less severe, competitors develop innovations that are applied by their competitor rather quickly towards a similar product. If there is only one supplier of a product innovation RWS often doesn't want to buy it and can even exclude it to be applied.
Amount of similar products	Yes			
Organizational level				
Slack resources	Yes	Yes		After the financial crisis there was little money available for new innovations to be developed and

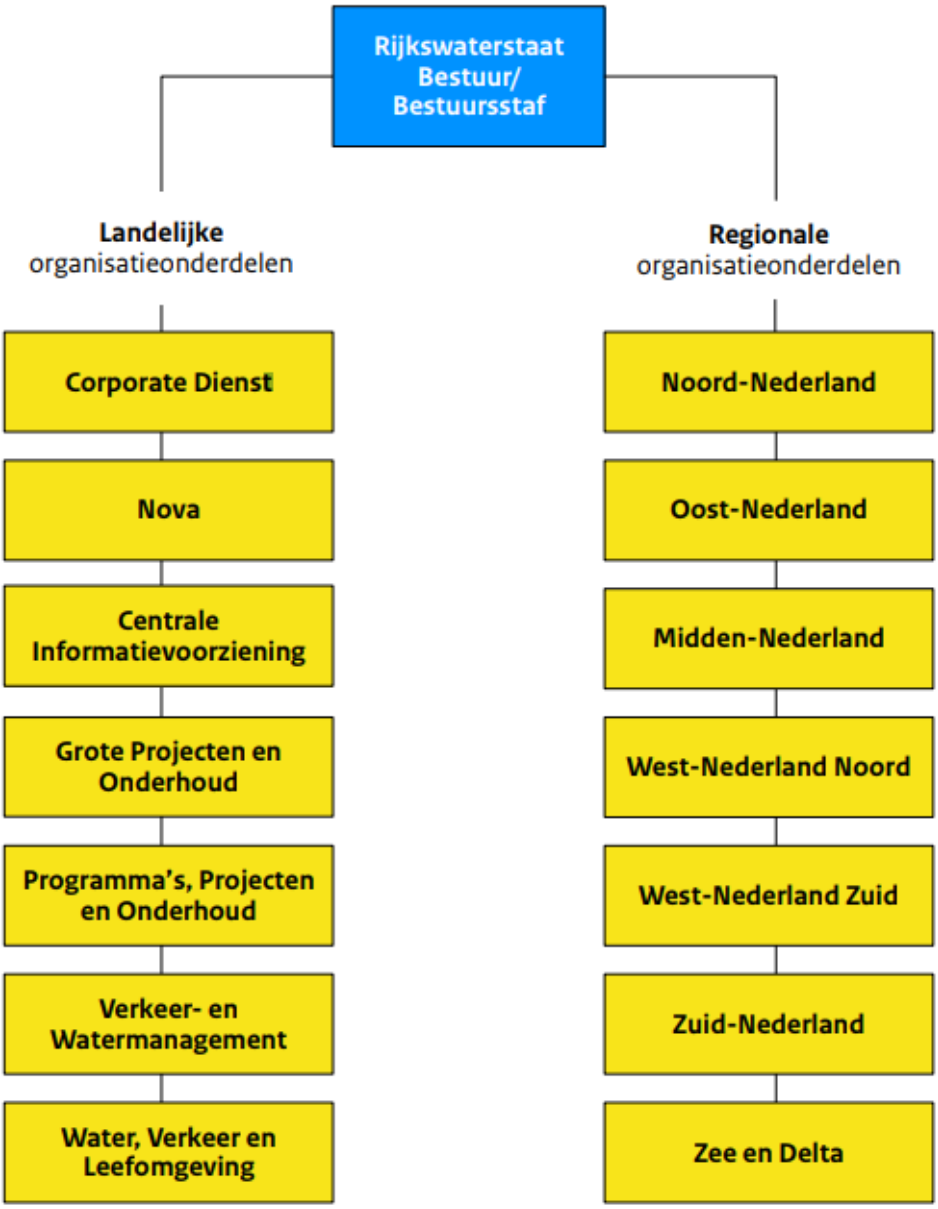
				applied. There is still some reluctance in doing so.
Financial impact	Yes	Yes	Low integral costs would stimulate the upscaling of a product to be applied and scaled up.	Tendering costs are too high. Often 0,8% - 1,0% of the contracting sum where the compensation is mostly 25% - 33%. Especially an issue for large projects of 100 million euro. Uncertain return on investment and profit due to unknown market opportunities to apply innovations in future projects.
Incentives and rewards	Yes			
Learning capability	Yes	Yes		
Degree of risk aversion	Yes	Yes	If RWS took a greater share of the risks related to product innovations, especially for radical innovations.	If there are too many risks for the contractor they are not willing to implement innovations.
Leadership style / management support	Yes	Yes		
Norms, roles and social networks	Yes	Yes		
The contract (size, duration, specification and award criteria)	Yes	Yes	MEAT can be a stimulant when it gives a significant reward related to the standards that are used. MEAT should result in distinctive outcomes, higher or lower grades should be given. Functional specifications can stimulate the implementation and upscaling of product innovations. A tender could prescribe that a % of the applied innovations should be patented. Clearly ask for innovations in tenders. Be clear how MEAT-criteria are measured. Dubocalc was a good initiative. It should not be the case that a contractor who “writes” sustainability better will receive higher scores.	The fictive price discount is in no relationship with the costs for an innovation in a project. MEAT doesn’t result in distinctive outcomes between contractors (often rated 7 or 8). Also the CO2 ladder level 5 or the “vehicle lost hours” can be achieved by almost every contractor so it isn’t distinctive in the MEAT. MEAT-criteria are minimal in a lot of tenders so it doesn’t make a difference. There is often no appreciation in tenders for innovative companies. In tenders the focus still lies towards price instead of quality, MEAT often doesn’t change it. Technical requirements still inhibit product innovations from being implemented.

			Standards could be described in order to do so. And give space for contractors where they can be distinctive. DBFM-contracts instead of D&C or RAW. It gives more space, stimulates innovations to be implemented and more focus will lie on the total life cycle of a product.	
Communication with the procuring body	Yes	Yes		Information about some innovations are not shared by the supplier or by RWS. RWS is reserved in making appointments. Afraid that they are favouring a company which is forbidden. It is hard to find the right persons at RWS to apply innovations. And after a technology was discussed it is hard to convince contract managers et cetera. Especially for totally new (radical) innovations it is often unclear who to talk to.
Isomorphism	Yes			
Communication about the innovation	Yes		RWS should discuss with the market about potential innovations and the risks which are involved and what regulations and legislations could hinder it and how to solve it.	Innovations are kept from each other, not shared by the supplier or RWS. A lack of communication from the supplier and RWS to discuss and solve problems related to innovations. RWS is very slow in their communication towards new developments and innovations. It can take years to get a clear answer.
Degree of publicity of an innovation	Yes			
Company's image and reputation	Yes			
Influence of stakeholders	Yes	Yes		
Requirements and wishes		Yes	RWS should take into account if a contractor has a good ISO qualification around their innovation processes.	In a lot of projects alternative solutions can't be applied.

			RWS should make space for alternative solutions to be implemented.	
Price compared to quality		Yes		Related to the tender, but price is still more important in tenders than quality.
Procurement process		Yes	A dialogue or market consultation can help to adjust requirements if RWS is also willing to adjust them.	Often there is little time between the application and the tender itself. Adjustments are not made very often by RWS. Therefore they rely on existing and well-known technologies. During a market consultation or dialogue session contractors are afraid to put their innovation on the table. It is often not clear how MEAT-criteria are measured which makes it hard to compare contractors and innovations with each other. The contracting department of RWS isn't involved enough during the developments and testing stages of a product innovation. Also innovations stimulated in a program or contest were chosen by RWS but the contracting department was never involved and therefore it couldn't be applied in a project.
Organization and industry culture		Yes		A lot of innovations such as roadside systems and in-car technology are related to companies in the automotive industry, contractors are originally constructers.
Innovation level				
Relative advantage	Yes	Yes	If the product innovation is more cost-effective than the product it supersedes.	The lifetime of a product is often not changed to give all market participants an equal chance in a tender. Advantages such as the life time are not always certain since it is not always clear.
Compatibility	Yes			
Complexity	Yes	Yes		Risks related to the complexity can sometimes be a barrier to adopt and implement an innovation.
Trialability	Yes	Yes		
Observability	Yes	Yes		

Availability of the technology	Yes	Yes		If RWS wants to be the owner of the patent after it was applied it is seen as a barrier to develop and implement a product innovation.
Standardisation of the technology	Yes			Tenders doesn't stimulate innovations, especially financially, to be adjusted so often more standard products which are proven and cheaper are applied.
Specifications in a tender		Yes	If the tender gives space towards innovations to be applied.	Innovations should comply to a lot of restrictions in tenders which makes it impossible to implement. There is little space to apply new innovations or to adjust tenders.
Individual level				
Employee autonomy	Yes			
Capabilities	Yes	Yes		
Creativity	Yes			
Risk aversion		Yes		There is a tendency to avoid risks related to innovations. Especially RWS is avoiding risks in large projects but also contractors due to the high fines in the contract.
Commitment	Yes			
Job satisfaction	Yes			
Shared perspectives and norms	Yes			It differs between people if they call a product innovation "proven" and want to apply it. People of RWS and the market often stick to their old habits and knowledge.
Types of groups an individual is in	Yes	Yes		
Innovativeness	Yes	Yes		
Behavioural/psychological factors		Yes		

Appendix G – Organogram Rijkswaterstaat



Appendix H – Procurement Plan Rijkswaterstaat

inkoopplan

Contractnummer:

1 Identificatie

Projectnaam	Zaakonderwerp	Datum:	
SAP nr		Documentnr.:	
Contractnr	Zaaknummer	Versie:	
		Bijlage(n):	

Opdrachtgevende dienst (OGD)	
Evt: opdrachtnemende dienst (OND)	
Projectleider	
Accountmanager	
Projectmanager	
Contractmanager	
Adviseur inkoop(ondersteuning)	
Opsteller	

	Naam	Functie	Ondertekening
Vastgesteld door			

2 Inkoopbehoefte

2.1 Aanleiding

2.2 Omschrijving project, contract

2.3 Motivering, doelstelling

2.4 Kwaliteit, resultaat, eisen aan product

2.5 Randvoorwaarden en uitgangspunten

2.6 Relatie met andere relevante, gerelateerde inkooptrajecten

3 Raming

3.1 Raming

De raming voor de inkoop bedraagt: €…
De onderbouwing van de raming is als volgt:

3.2 Budget, begroting,

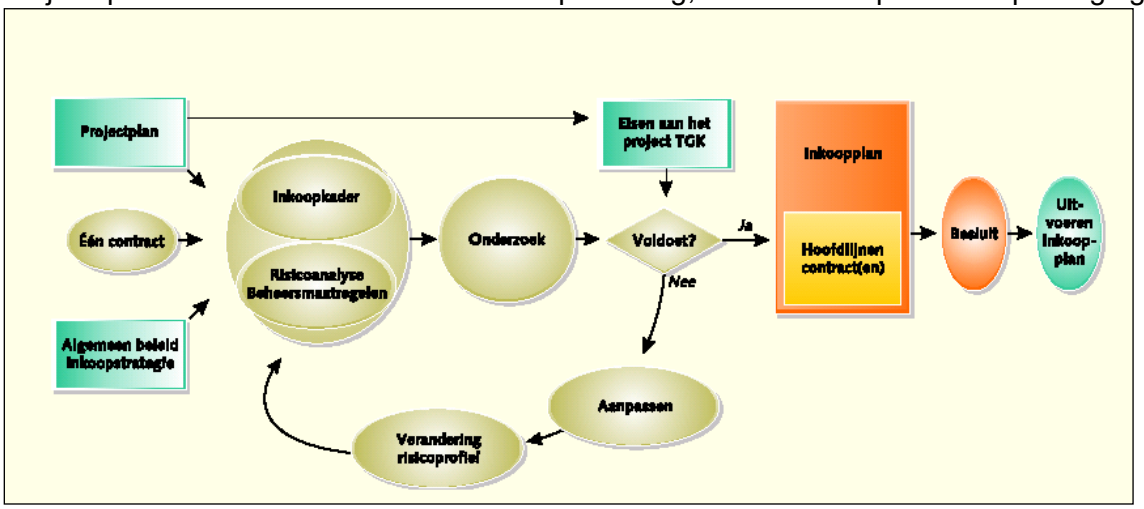
Voor de inkoop is het volgende budget beschikbaar:

3.3 Uitgavenoverzicht (in de tijd)

4 Inkoopafweging

4.1 Inkoopkader

Voor deze inkoop geldt het volgende afwegingskader:
(Verwijzing naar de corporate inkoopstrategie en eventuele (Regionale) afgeleiden daarvan, kort gemotiveerd. Positie van de inkoop binnen overige inkopen; inkoopbundeling. Projectspecifieke onbekendheden en risicoprofilering, van invloed op de inkoopafweging).



Om voor de inkoop een heldere en eenduidige afweging te kunnen maken hanteert RWS het zgn. Afwegingsmodel Inkoopproces (zie bovenstaande figuur). Hiermee wordt een juiste rol- en risicoverdeling tussen RWS en marktpartijen verkregen. Het Afwegingsmodel is een cyclisch model waarbij steeds hetzelfde denkproces wordt doorlopen. Het model start met een eerste werkhypothese (een aanname voor een bepaalde inkoopvorm die normaliter uitgaat van zo veel mogelijk markt). Onderzoek moet uitwijzen of de werkhypothese een goede inkoop oplevert of dat bijstelling van de werkhypothese noodzakelijk is. Het resultaat van het doorlopen van dit model is een goedgekeurde Inkoopplan. Het strategische kader (inkoopstrategie) en de operationele inkoop vallen buiten het toepassingsgebied van het Afwegingsmodel.

4.2 Afweging

Het toepassen van het afwegingsmodel inkoopproces heeft de volgende resultaten opgeleverd:

4.3 Resultaat inkoopafweging

In hoofdlijnen ziet het contract er als volgt uit: Korte beschrijving van het contractuele kader als uitkomst van de inkoopafweging

5 Risico’s

5.1 Inventarisatie

5.2 Kans en impact

5.3 Beheersmaatregelen

6 Marktbenadering

6.1 Marktanalyse
Een uitgevoerde marktverkenning heeft de volgende inzichten verschaft:

6.2 Contractvorm incl. beheersing
Het volgende contractmodel zal worden gebruikt:

6.3 Aanbestedingsvorm

Het contract zal op de volgende wijze op de markt worden gezet: (verwachte marktbenadering)
Bij de volgende bedrijven zal offerte worden aangevraagd:

6.3.1 Selectie

6.3.2 Gunningcriteria

7 Planning

7.1 Activiteiten

7.2 Mijlpalen

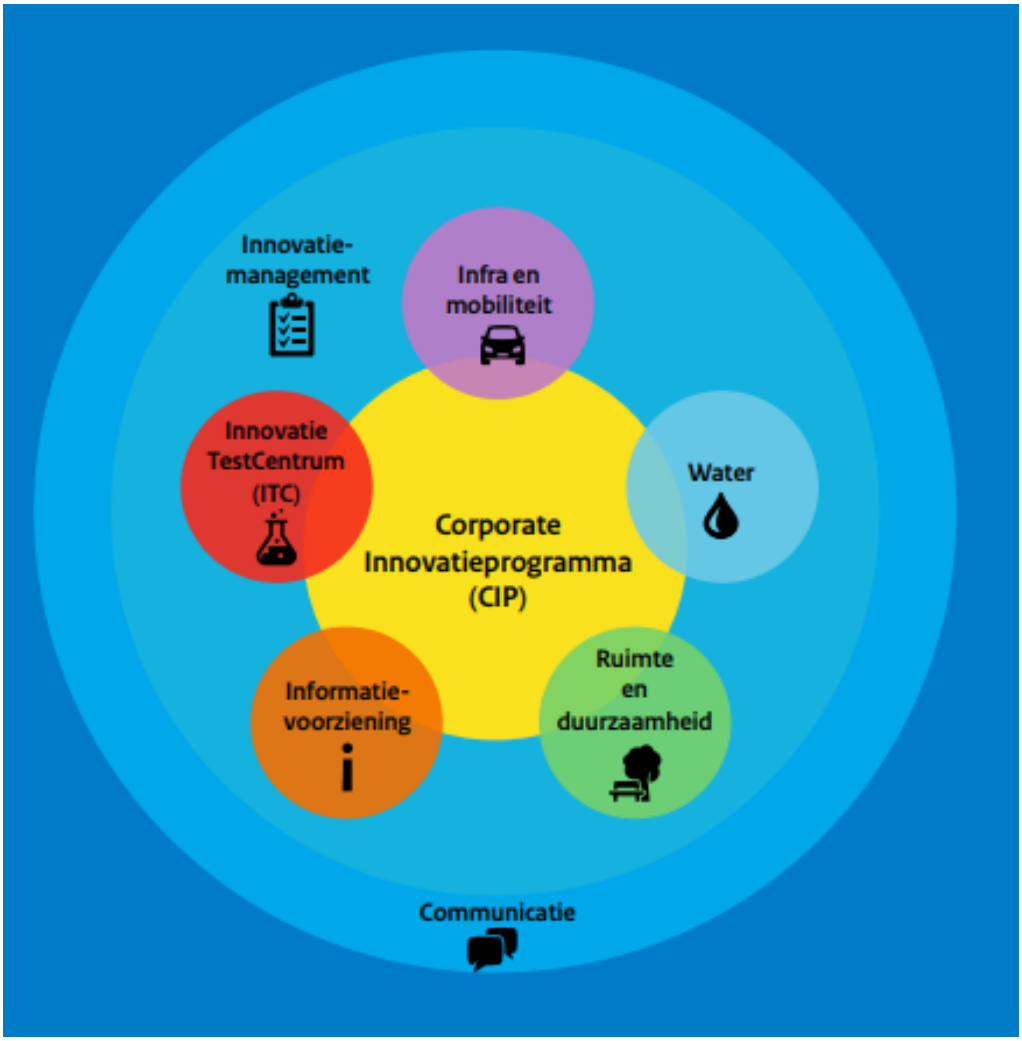
7.3 Go / No-go

Appendix I – Overview GPO-projects Rijkswaterstaat

Phases of GPO-projects, retrieved on 9-12-2015.

GPO Realisation portfolio	**Contract type**	**Region**
A28/A1 Knooppunt Hoevelaken	PD&C	MN
A27/A1 Utrecht knpt. Eemnes aansl. Bunschoten	DBFM	MN
N31 Haak om Leeuwarden	D&C	NN
N31 Harlingen (Traverse Harlingen)	D&C	NN
A6/A7 Knooppt Joure	D&C	NN
A7 Zuidelijke Ringweg Groningen	D&C	NN
A50 Ewijk - Valburg	D&C	ON
A12 Ede-Grijsoord	DBFM	ON
N35 Combiplan Nijverdal	D&C	ON
N18 Varsseveld - Enschede	DBFM	ON
A1 Apeldoorn Zuid - Beekbergen	D&C	ON
N35 Zwolle - Wijthmen (Ganzepan)	D&C	ON
A10 Tweede Coentunnel / A5 Westrandweg	DBFM	WNN
Omlegging A9 Badhoevedorp	D&C	WNN
A4 Delft Schiedam	D&C	WNZ
A15 Maasvlakte-Vaanplein	DBFM	WNZ
A4 Burgerveen - Leiden	D&C	WNZ
N61 Hoek - Schoondijke	D&C	Z&D
A2 passage Maastricht	D&C	ZN
Projects (around 1 billion) related to a program	**Contract type**	**Region**
SAA: A10 Oost	D&C	WNN
SAA: A9 Amstelveen	DBFM	WNN
SAA: A1/A6	DBFM	WNN
SAA: A6 Almere	DBFM	WNN
SAA: A9 Gaasperdammerweg	DBFM	WNN
GPO Plan elaboration and preparation realisation portfolio	**Contract type**	**Region**
A27/A12 Ring Utrecht	nnb	MN
A1 Apeldoorn - Azelo (fase 1 en 2)	D&C	ON
A12/A15 Ressen - Oudbroeken	DBFM	ON
N35 Nijverdal - Wierden	D&C	ON
A13/A16/A20 Ring Rotterdam	DBFM	WNZ
A24 Blankenburgverbinding	DBFM	WNZ
A27 Houten Hooipolder	nnb	ZN
Projects in discharge/transfer	**Contract type**	**Region**
A4 Dinteloord - Bergen op Zoom	PD&C	ZN
N33 Assen-Zuidbroek	DBFM	NN
A28 Utrecht - Amersfoort (GOVER)	D&C	MN
N50 Ramspol - Ens	D&C	ON
A2 's-Hertogenbosch - Eindhoven	D&C	ZN
Total amount of PD&C contracts	**2**	**6%**
Total amount of D&C contracts	**19**	**56%**
Total amount of DBFM contracts	**13**	**38%**
	34	**100%**

Appendix J – Corporate Innovation Program (CIP)



Focus areas (clusters):

Purple:	Infra and Mobility
Blue:	Water
Green:	Spatial and sustainability
Orange:	Information supply
Red:	Innovation Test Centre (ITC)
	Innovation Management