Optimizing the management of risks related to product innovations in the construction industry, in the context of the Innovation Partnership

Michelle Koopmans

Flux Partners

TU Delft

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Author

Name:	M.J.P. (Michelle) Koopmans
Student number:	4676432
Email:	michelle_koopmans@live.nl
Master:	Construction Management and Engineering
Institution:	Delft University of technology
Faculty:	Civil Engineering and Geosciences

Company supervision

Company:	Flux Partners
First supervisor:	ir. M.A. (Michiel) Schroten
Second supervisor:	ir. J. (Jesse) van der Mieden

Supervisory board TU Delft

Chair of the committee:	prof.mr.dr. E.M. (Evelien) Bruggeman
First supervisor:	ir. L.P.I.M. (Leon) Hombergen
Second supervisor:	dr.ir. L.S.W. (Leonie) Koops

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"Man cannot discover new oceans unless he has the courage to lose sight of the shore"

~ André Guide

Preface

Five years ago, at this time (November 2016), I was preparing for an adventure in South America. After receiving my bachelor degree in Building Engineering with a specialization in structural engineering at the Hogeschool van Amsterdam in 2016, I was not ready to start working. So, I decided to travel to South America. I applied for the master of Construction Management and Engineering (CME) at the Technical University of Delft to have something to return for, and utilize the desire to expand my knowledge. In September 2017, I started the pre-master, and in February 2018, I officially began the master CME. During the master, I developed an interest in procurement and building contracts. Hence, when Flux Partners was looking for a graduate student in the area of the Innovation Partnership, it felt like the right fit.

During the past year, I experienced many ups and downs. Therefore I owe a big thank you to everyone who supported me during this year. First, I would like to thank my supervisors of Flux Partners; Michiel Schroten and Jesse van der Mieden. Thank you for all the time you have put into my graduation process, and thank you for sharing all your knowledge and expertise. In addition, I want to thank all my colleagues at Flux partners for their help with my research, their interest in my research, and for all the support I received. Also, I want to thank my supervisors from the TU Delft; Leon Hombergen, Leonie Koops, and Evelien Bruggeman. I appreciate the effort and time you put into helping me with my research and providing me with your knowledge on the subject. Thank you for motivating me to fulfill my potential.

Then, I want to thank my friends and family for their support when I struggled and for their love when celebrating my successes. In particular, I want to thank my parents Monique and Ruurd, for always believing in me and helping me where they could. Also, thank you, Louise, for supporting me by sharing your own experiences with a graduation process. And, thank you to my friends for all the support during, sometimes a little long, coffee breaks and the joint study sessions.

To conclude, a special thanks to Joren for always emphasizing with me. You were there when I needed help, when I needed to express my frustrations, and for the celebratory moment, you were the one to bring the champagne. Thank you for that. Now, I have come to the end of yet another adventure. I am excited to start with the next chapter in my life.

Michelle Koopmans
Delft, November 2021

Summary

Introduction

The sustainability and circularity goals, the PFAS and Nitrogen regulations, and the renovation and replacement of existing infrastructure require the inclusion of product innovations in the construction industry. This research addresses two aspects of innovation: procurement of innovation and uncertainty of innovations.

An Innovation Partnership is a procurement procedure developed to facilitate the inclusion of product innovations in a construction project. The procedure was added to the Dutch and the European procurement law in 2016.

Due to the novelty of innovation (definition: A new or significantly improved product, which improves productivity and quality of the project outcome), more uncertainty is introduced in the project, and not all uncertainties can be foreseen, which can cause risk aversion. To overcome risk aversion, the allocation of responsibilities in projects with innovation has to be optimized.

Research question

The research consists of three main subjects: innovation, the Innovation Partnership, and risk management. These subjects form the basis of the main research question:

*How can an **Innovation Partnership** stimulate **innovation** in the construction industry by dealing with **uncertainties** related to product innovation?*

Five sub-questions help to answer the main question:

1. How does the procurement of innovation facilitate the need for innovation in construction projects?
2. What uncertainties relate to innovation in construction projects?
3. How does the Innovation Partnership deal with barriers for the implementation of product innovations in construction projects?
4. How does the use of a product innovation in a project affect the way risks and uncertainties related to innovation are managed in a project?
5. How, in current practice, are innovations included in construction projects?

Methodology

A literature study is conducted to compile a theoretical understanding of innovation, procurement of innovation, and management of uncertainties of innovation. Through interviews, practical insight into innovation barriers, the Innovation Partnership, and unforeseen events are gathered. The results are a comparison between literature and practice. Finally, the results are validated through an expert session.

Innovation

Innovations are introduced in construction projects through procurement procedures to answer the need for innovation in the Netherlands and the construction industry. The traditional way of thinking must be replaced with proposing radical ideas to facilitate the needed transition. Furthermore, it benefits contractors and contracting authorities through cost reductions, the establishment of competitive advantage, and increased quality and productivity.

Innovations are publicly procured following the Dutch and European procurement law when the project exceeds the tender threshold. Innovating through procurement facilitates the contracting

authority as they can find the missing expertise and knowledge in an external party. However, if the contracting authority requests innovation in their tender invitation, they enter into a demand-pull process. In a demand-pull innovation process where innovations are derived from a market need. In contrast, in a technology-push innovation process, innovation is derived from basic science. Studies show that technology-push-based innovations are more radical, whereas demand-pull innovations tend to be more incremental.

The innovation Partnership

An Innovation Partnership is a procedure that includes the Research and Development (R&D) of an innovation within the procurement process. The Innovation Partnership includes four stages: Formulation of the tender, Tender phase, research and development phase, and implementation phase, see figure 2.

Phase of the project	**Phase 1; Formulation of the tender**	**Phase 2; Tender phase**	**Phase 3; Research and development**	**Phase 4; Implementation**
Contracting authority	• Problem formulation • Market consultation • Choice of procurement procedure	• Tender invitation • Exclusion of candidates based on selection criteria	• Selection of participants for the research and development phase • Go/no-go moments • Final contract awarding • Contract for execution	• Realisation of the project • Implementation of the innovation
Contractor	• Explore interest in the project	• (optional) Formation of consortium • Formulate tender • Submit tender	• Development of innovation • Go/no-go moments • Get project awarded	• Execution of the project • Implementation of the innovation
Design stage	*Sketch design*	*Temporary design*	*Definitive design*	*Execution design*

Figure 2: The procedure of an Innovation Partnership

Barriers to innovation, identified by literature and mentioned in the interviews that an Innovation Partnerships can handle include:

- **Recognition of the value of innovation**: the contracting authority will only use an Innovation Partnership when they recognize that an innovation adds value to the project.
- **Incentive to come up with innovative solutions**: the contracting authority indicates the need for innovation in the project. That creates the incentive for the market to come up with innovative solutions.
- **Standards and regulations**: products that are traded on the market need to meet specific safety and quality standards and regulations. The government sets up these standards and regulations, and they are strict to ensure safety and quality. For the development of a new product, the standards and regulations can form a hindrance when the product innovation does not meet them. The standards and regulations can be adjusted whenever the product innovation proves to meet the functional requirements of the standards and regulations. To prove this, the product innovations must be tested in a relevant environment. The long duration of a testing period forms a barrier to implementing a product innovation. Testing the innovation is one of the steps of the TRL-ladder (Technology Readiness Level). During the R&D phase of an Innovation Partnership, the innovation will be developed in accordance with the TRL-ladder. Therefore, testing the product is included in the R&D phase of the Innovation Partnership.
- **Stakeholder readiness**: an Innovation Partnership facilitates the possibility to engage and involve stakeholders from in an early stage of the project. Whenever stakeholders are not ready for the innovation, it can cause resistance. The readiness of stakeholders can be improved by informing and engaging them prior to and during the development and implementation of the product innovation in the project.

Risk management

Two types of uncertainties are distinguished: foreseeable uncertainty and unforeseeable uncertainty. Foreseeable uncertainties are dealt with through risk management. The general approach is to identify the risks, assess the risks, and allocate the risks. When a product innovation is included in the project, not all risks can be identified upfront. The novelty of the product innovation hinders the upfront identification of risks.

The allocation of risks is arranged in contractual agreements. Four contractual models are considered: the traditional model, the integrated model, a Bouwteam (design team) model, and an alliance. For a project that includes a product innovation, the most applicable contractual agreement depends on the project phase. The level of uncertainty related to the product innovation depends on the project phase. The level of uncertainty decreases along with the duration of the project. Therefore, the allocation of risks is specific for four project phases: Problem definition, design and R&D, execution, and maintenance and operations. The project phases that include a high level of uncertainty should include a joint gain and loss sharing approach.

Sharing of risks (possible profit or losses) is not self-evident. Profit is not the same for the contractor and the contracting authority. For the contracting authority, profit or surplus-value is the difference between the created value of the project and the price they paid for the project. In contrast, surplus value for the contractor consists of the difference between project delivery costs and the price they get paid for the completed project. To establish an equal collaboration and reach joint goals, the surplus-value of the alliance partners has to be equalized. The alliance fund equalized the surplus-value. It can be used to pay costs and possible losses, and the remaining credit can be shared at the end of the project.

Conclusion

To stimulate innovation through an Innovation Partnership, the uncertainties related to product innovations should be managed following the level of uncertainties of the product innovation in the specific project stages. The level of uncertainty surrounding the product innovation reduces after the R&D phase of the Innovation Partnership. The way risks should be managed in the four project phases: problem definition phase, design and R&D phase, execution phase, and maintenance and operations phase, to stimulate innovation through the Innovation Partnership is:

- **Problem definition phase**; Contracting authority formulates the tender invitation for which they are liable. The tender invitation should include a minimal number of functional specifications to stimulate radical innovation proposed by the market. Here, there are no shared responsibilities.
- **Design and R&D phase**; Contracting authority and contractor form a design alliance in which profits and losses are shared through the use of an alliance fund. In the R&D phase, the uncertainties related to the innovation are the highest. Shared responsibilities include the definition of the project goal, agree upon intellectual property rights, set up an alliance fund, negotiating what risks are allocated and what risks are shared.
- **Execution phase**; The risks in the execution phase of a project including a product innovation consists of two parts: (1) risks related to the general project and (2) risks related to the product innovation. Because the innovation is developed and tested during the R&D phase, uncertainty with the innovation is reduced. Therefore, the project in general can be executed by using an UAV-GC. In addition to the execution contract, an alliance module should be added to cover the risks that relate to the product innovation. Joint responsibilities in this phase include risks related to the product innovation.
- **Maintenance and operation phase**; With the maintenance and operation phase, the responsibilities of the innovation are transferred to the future owner of the project. The contractor and the contracting authority can only be held liable when a defect occurs that is proven to be caused during the execution phase or the R&D phase.

Recommendations

This report concludes with practical recommendations on the subjects of innovation, the Innovation Partnership, and risk management. For innovation in general, both the contractor and the contracting authority should acknowledge the benefits coming from innovation. For the contractor, the benefits could be creating a competitive advantage and continuously meeting the requirements following the sustainability goals. For the contracting authority, innovation can be beneficial to meet future legislation, increase productivity, and improve quality.

For the Innovation Partnership procedure, recommendations are to engage stakeholders (Key players, context setters, and subjects) prior to, during, and after the project to prevent resistance. Another recommendation for the contracting authority is to minimize the number of technical requirements to utilize the innovativeness of the market to provide space for radical innovations proposed by contractors.

Recommendations for risk management include recognizing the difference between the execution phase and the R&D phase of the Innovation Partnership. The R&D phase of an Innovation Partnership requires an alliance agreement that shares risks and gains through an alliance fund. The uncertainties reduce whenever the innovation is tested en ready for the execution, then the project can be executed governed by an UAV-GC. However, in addition to the UAV-GC an alliance module must be put into place for the occurrence of risks related to the innovation.

Samenvatting

Introductie

De duurzaamheids- en circulariteitsdoelen, de PFAS- en stikstofregelgeving en de benodigde renovatie en vervanging van bestaande infrastructuur, vereisen het opnemen van productinnovaties in bouwprojecten. Dit onderzoek richt zich op twee aspecten van innovatie: inkoop van innovatie in bouwprojecten en de onzekerheden gerelateerd aan innovaties.

Een Innovatiepartnerschap is een aanbestedingsprocedure die is ontwikkeld om de opname van productinnovaties in bouwprojecten te vergemakkelijken. De procedure is in 2016 toegevoegd aan de Nederlandse en de Europese aanbestedingswet. Door de nieuwheid van innovatie (definitie: een

nieuw of aanzienlijk verbeterd product, dat de productiviteit en kwaliteit van het projectresultaat verbetert), wordt er meer onzekerheid in het project geïntroduceerd en zijn niet alle onzekerheden te voorzien, wat tot risicomijding kan leiden. Om risicomijding te overwinnen, moet de toewijzing van verantwoordelijkheden in projecten met innovatie worden geoptimaliseerd.

Onderzoeksvraag

Het onderzoek bestaat uit drie hoofdonderwerpen: innovatie. Het Innovatiepartnerschap en risicomanagement. Deze onderwerpen vormen de basis van de onderzoeksvraag:

*Hoe kan een **Innovation Partnership innovatie** in de bouwsector stimuleren door om te gaan met **onzekerheden** gerelateerd aan productinnovatie?*

De volgende vijf deelvragen helpen bij het beantwoorden van de hoofdvraag:

- Hoe faciliteert het inkopen van innovatie de behoefte aan innovatie in bouwprojecten?
- Welke onzekerheden hebben betrekking op innovatie in bouwprojecten?
- Hoe gaat het Innovatiepartnerschap om met hindernissen voor het doorvoeren van productinnovaties in bouwprojecten?
- Hoe beïnvloed het gebruik van productinnovaties in een project de manier waarop risico's en onzekerheden, gerelateerd aan innovatie in een project, worden gemanaged?
- Hoe worden innovaties in de huidige praktijk meegenomen in bouwprojecten?

Methodologie

Het onderzoek begint met een literatuurstudie om een theoretische basis te vormen op het gebied van innovatie, inkoop van innovatie en de beheersing van onzekerheden gerelateerd aan innovatie. Door middel van interviews wordt praktisch inzicht verkregen in hindernissen voor innovatie, het Innovatiepartnerschap en onvoorziene gebeurtenissen. Ten slotte worden de uitkomsten van de interviews gevalideerd door middel van een expertsessie.

Innovatie

Innovaties worden in bouwprojecten geïntroduceerd via aanbestedingsprocedures on te voldoen aan de behoeft aan innovatie in de Nederlandse bouwsector. De traditionele manier van denken moet worden vervangen door het inbrengen van radicale ideeën om de benodigde transitie te faciliteren. Bovendien komt het ten goede aan aannemers en de aanbestedende diensten door kostenverlaging, het creëren van concurrentievoordeel en een verhoging van kwaliteit en productiviteit.

Innovaties worden volgens de Nederlandse en Europese aanbestedingswet openboor aanbesteed wanneer het project de aanbesteding drempel overschrijdt. Innoveren door middel van aanbesteden faciliteert de aanbestedende dienst om hun ontbrekende expertise en kennis te verkrijgen bij een externe partij. Als de aanbestedende dienst om een innovatie vraagt in de uitvraag, gaan zij een demand-pull innovatieproces aan. In een demand-pull innovatieproces wordt de vraag naar innovatie afgeleid van de markt behoefde. Daarentegen in een technologie-push innovatieproces wordt innovatie ontwikkeld vanuit fundamentele wetenschap. Studies tonen aan dat op technology-push innovaties radicaler zijn, terwijl demand-pull-innovaties meer incrementeel zijn.

Het Innovatiepartnerschap

Een innovatiepartnerschap is een aanbestedingsprocedure die het onderzoek en de ontwikkeling (O&O) van een innovatie in het inkoopproces bevat. Het Innovatiepartnerschap kent vier fasen: het opstellen van de aanbesteding, de aanbestedingsfase, de onderzoeks- en ontwikkelingsfase en de uitvoeringsfase, zie figuur 3.

Projectfase	**Fase 1; Formuleren van de uitvraag**	**Fase 2; Tender fase**	**Fase 3; Onderzoek- en ontwikkelingsfase**	**Fase 4; Uitvoering**
Aanbestedende dienst	• Probleem formulering • Marktconsultatie • Keuze foor aanbestedingsprocedure	• Uitvraag • Uitsluiting van deelnemers op basis van uitsluitingscriteria	• Selectie van deelnemers aan de O&O fase • Go/no-go momenten • Definitieve gunning van het contract voor de uitvoering	• Realisatie van het project • Implementatie van de innovatie
Aannemer	• Interesse in het project onderzoeken	• (optioneel) Consortium vormen • Tender schrijven • Inschrijven	• Ontwikkeling van de innovatie • Go/no-go momenten • Contract gegund krijgen	• Realisatie van het project • Implementatie van de innovatie
Ontwerpfase	*Schetsontwerp*	*Tijdelijk ontwerp*	*Definitiefontwerp*	*Uitvoeringsontwerp*

Figure 3: De procedure van het Innovatiepartnerschap

Hindernissen voor innovatie, geïdentificeerd door literatuur en genoemd in de interviews waar het Innovatiepartnerschap mee om gaat zijn ondermeer:

- **Erkenning van de waarde van innovatie**: de aanbestedende dienst zal alleen gebruik maken van een Innovatiepartnerschap als hij erkent dat een innovatie waarde toevoegt aan het project.
- **Prikkel om innovaties te ontwikkelen**: de aanbestedende dienst geeft de noodzaak aan voor innovatie in het project. Dat creëert een prikkel voor de markt om innovaties te ontwikkelen.
- **Standaarden en regelementen**: producten die op de markt worden verhandeld, moeten voldoen aan specifieke veiligheids- en kwaliteitsnormen en voorschriften. De overheid stelt deze normen en voorschriften op om de veiligheid en kwaliteit te waarborgen. Voor de ontwikkeling van een nieuw product kunnen de normen en regelgeving een belemmering vormen wanneer de productinnovatie daar niet aan voldoet. De normen en voorschriften kunnen worden aangepast wanneer is bewezen dat de productinnovatie voldoet aan de functionele eisen van de normen en voorschriften. Om dit te bewijzen, moeten de productinnovaties worden getest in een relevante omgeving. De lange duur van een testperiode vormt een drempel om een productinnovatie door te voeren. Het testen van de innovatie is een van de stappen van de TRL-ladder (Technology Readiness Level). Tijdens de O&O-fase van een Innovatiepartnerschap wordt de innovatie ontwikkeld volgens de TRL-ladder. Daarom is het testen van het product opgenomen in de O&O-fase van het Innovatiepartnerschap.
- **Stakeholder readiness**: een innovatiepartnerschap faciliteert de mogelijkheid om belanghebbenden al in een vroeg stadium van het project te betrekken en te betrekken. Wanneer stakeholders niet klaar zijn voor de innovatie, kan dit weerstand oproepen. De gereedheid van

stakeholders kan worden verbeterd door hen voorafgaand aan en tijdens de ontwikkeling en implementatie van de productinnovatie in het project te informeren en hen bij het project te betrekken.

Risicomanagement

Er worden twee soorten onzekerheden onderscheiden: voorzienbare onzekerheden en onvoorzienbare onzekerheden. Voorzienbare onzekerheden worden opgevangen door middel van risicomanagement. De algemene benadering is om de risico's te identificeren, de risico's te beoordelen en de risico's toe te wijzen aan een van de betrokken partijen. Wanneer een productinnovatie in het project wordt opgenomen, zijn niet alle risico's vooraf in kaart te brengen. De nieuwheid van de productinnovatie belemmert het vooraf identificeren van risico's. De allocatie van risico's wordt

geregeld via contractuele afspraken. Er worden vier contractuele modellen beschouwd: het traditionele model, het geïntegreerde model, een Bouwteam model en een alliantie. Voor een project met een productinnovatie is de meest geschikte contractuele afspraak afhankelijk van de projectfase. De mate van onzekerheid met betrekking tot de productinnovatie is namelijk afhankelijk van de projectfase. De mate van onzekerheid neemt af met de duur van het project. De allocatie van risico's is daarom specifiek voor vier projectfasen: probleemdefinitie, ontwerp en R&D, uitvoering en onderhoud en exploitatie. De projectfasen met een hoge mate van onzekerheid moeten een gezamenlijke benadering van winst- en verliesdeling omvatten. Het delen van risico's (winst of

verlies) is niet vanzelfsprekend. Winst is niet hetzelfde voor de opdrachtnemer en de aanbestedende dienst. Voor de aanbestedende dienst is winst het verschil tussen de gecreëerde waarde van het project en de prijs die zij voor het project hebben betaald. De meerwaarde voor de aannemer daarentegen bestaat uit het verschil tussen de opleveringskosten van het project en de prijs die hij voor het voltooide project betaald krijgt. Om een gelijkwaardige samenwerking tot stand te brengen en gezamenlijke doelen te bereiken, moet de meerwaarde van de alliantiepartners worden vereffend. Het alliantiefonds maakte de meerwaarde gelijk. Het kan worden gebruikt om kosten en eventuele verliezen te betalen, en het resterende krediet kan aan het einde van het project worden gedeeld.

Conclusie

Om innovatie te stimuleren via het Innovatiepartnerschap, moeten de onzekerheden met betrekking tot productinnovaties worden beheerst volgens het niveau van onzekerheid gerelateerd aan de productinnovatie in de specifieke projectfasen. De mate van onzekerheid rond de productinnovatie neemt af na de O&O-fase van het Innovatiepartnerschap. De manier waarop risico's moeten worden beheerd in de vier projectfasen: probleemdefinitiefase, ontwerp- en O&O-fase, uitvoeringsfase en onderhouds- en exploitatiefase, om innovatie te stimuleren via het innovatiepartnerschap is als volgt:

- **Probleemdefinitie fase**; de aanbestedende dienst formuleert de uitvraag waarvoor hij aansprakelijk is. De aanbesteding moet het aantal functionele specificaties minimaliseren om de markt te stimuleren om radicale innovaties aan te dragen. In deze fase zijn er geen gedeelde verantwoordelijkheden.

- **Ontwerp- en O&O-fase**; aanbesteder en opdrachtnemer vormen een ontwerpalliantie waarin winst en verlies worden gedeeld door middel van een alliantiefonds. In de O&O-fase zijn de onzekerheden met betrekking tot de innovatie het grootst. Gedeelde verantwoordelijkheden omvatten het definiëren van het projectdoel, overeenstemming bereiken over intellectuele eigendomsrechten, het opzetten van een alliantiefonds, onderhandelen over welke risico's worden toegewezen en welke risico's worden gedeeld.

- **Uitvoeringsfase**; De risico's in de uitvoeringsfase van een project met een productinnovatie bestaat uit twee delen: (1) risico's gerelateerd aan het algemene project en (2) risico's gerelateerd aan de productinnovatie. Doordat de innovatie in de O&O-fase wordt ontwikkeld en getest, worden de onzekerheden gerelateerd aan de innovatie verminderd. Daarom kan het algemene project worden uitgevoerd op basis van een UAV-GC. Naast het uitvoeringscontract dient een alliantiemodule te worden toegevoegd om de risico's die samenhangen met de productinnovatie af te dekken. Gezamenlijke verantwoordelijkheden in deze fase omvatten risico's die verband houden met de productinnovatie.

- **Onderhoud- en exploitatiefase**; Met de onderhouds- en exploitatiefase worden de verantwoordelijkheden van de innovatie overgedragen aan de toekomstige eigenaar van het project. De opdrachtnemer en de aanbestedende dienst kunnen in deze fase alleen aansprakelijk worden gesteld wanneer zich een gebrek voordoet waarvan bewezen is dat het is veroorzaakt tijdens de uitvoeringsfase of de O&O-fase.

Aanbevelingen

Dit rapport wordt afgesloten met praktische aanbevelingen op het gebied van innovatie, het Innovatiepartnerschap en risicomanagement. Voor innovatie in het algemeen geldt dat zowel de contractant als de aanbestedende dienst de voordelen van innovatie moeten erkennen. Voor de aannemer kunnen de voordelen bestaan uit het creëren van een concurrentievoordeel en het continu voldoen aan de eisen volgens de duurzaamheidsdoelstellingen. Voor de aanbestedende dienst kan innovatie gunstig zijn om te voldoen aan toekomstige wetgeving, het verhogen van productiviteit en het verbeteren van de kwaliteit.

Voor het Innovatiepartnerschap is het aanbevolen om belanghebbenden in een vroeg stadium en gedurende het hele project te betrekken om weerstand te voorkomen. Een andere aanbeveling voor de aanbestedende dienst is om het aantal technische eisen tot een minimum te beperken om de innovatiekracht van de markt te benutten en hen de ruimte te geven om radicale innovaties aan te dragen.

Aanbevelingen voor risicomanagement zijn onder meer het erkennen van het verschil tussen de O&O-fase van het Innovatiepartnerschap en de uitvoeringsfase. De O&O-fase van een Innovatiepartnerschap vereist een alliantieovereenkomst die risico's draagt via een alliantiefonds. De onzekerheden nemen af wanneer de innovatie is getest en gereed is voor uitvoering, waarna het project kan worden uitgevoerd aan de hand van een UAV-GC. Wel moet naast de UAV-GC een alliantiemodule worden ingericht voor het optreden van risico's die samenhangen met de innovatie.

Definitions

Table 1: Definitions

	Translation (based on Government of the Netherlands (2012))	**Definition (based on (European Commission, 2014))**
Contracting authority	*Aanbestedende dienst*	A state, regional or local authority, bodies governed by public law or associations formed by one or more such authorities or one or more such bodies governed by public law.
Contractor	*Aannemer*	Any company that offers the execution of works on the market.
Public works contract	*Concessieopdracht voor werken*	A public contract which includes the execution and/or design of a work or a contract which includes the realization of work meeting the requirement set by the contracting authority, who has a decisive influence on the design and type of the work.
Tender/bid	*Tender/bod*	The offer submitted by a contractor.
Tenderer	*Inschrijver*	A contractor which submitted a tender.
Candidate	*Gegadigde*	A party that wants a tender invitation or has been invited to take part in a procedure with participants selection.
Procurement/Tender documents	*Aanbestedingsstukken*	Any document produced or referred to by the contracting authority to describe or determine elements of the procurement or the procedure.
Tender invitation	*Uitvraag*	Presenting the procurement documents to the market, invite tenderers to submit a bid.

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1. Introduction

In August 2021, the IPCC climate report was published stating that climate change is progressing faster than ever (IPCC, 2021). Besides that, construction projects are at a standstill, waiting to hear about nitrogen regulations and the PFAS regulations. Therefore, innovation is no longer only a side issue; it is becoming essential (Rijksoverheid, 2018; European Commission, 2018; Arnoldussen et al., 2017).

1.1. Research context

To facilitate the implementation of innovation in the construction industry, in 2016, the procurement procedure Innovation Partnership was introduced in the European and Dutch procurement law (Government of the Netherlands, 2012; European Commission, 2014). The procedure is developed for projects where there is the need for an innovative product to solve the problem that can not be met by products already available, in the required form, on the market (Eadie & Potts, 2016). The Innovation Partnership includes the development and the implementation of an innovation in a project. The development is done through collaboration between the contractor and the contracting authority (Government of the Netherlands, 2012; PIANOo, 2020a).

A contracting authority is obligated to publicly procure when their project exceeds the tender threshold of €5.186.000 (European Commission, 2014). The contracting authority has a choice for what procurement procedure they will use to procure their project: Open/restricted procedure, competition with negotiations, competitive dialogue, Pre-commercial procurement, or Innovation Partnership. Each procedure has its characteristics and, thus, is suitable for specific projects. The choice of procedure is based on, among other things, the level of specification in the tender invitation (Twynstra Gudde, 2021; PIANOo, 2021; Mohsini, 1993).

Because the innovative product is "new," there is a high degree of uncertainty and even unforeseeable uncertainty (Rogers, 2003; Loch et al., 2006). The contracting authority and the contractor can manage uncertainties through risk management by identifying risks, risk assessment, and risk allocation (Schilling, 2018; Nicholas & Steyn, 2017). However, for unforeseeable uncertainty, upfront identification is not possible, but it can still have a significant impact on an innovation (Loch et al., 2008, 2006).

1.2. Problem formulation

Innovation is needed in the construction industry to meet the sustainability and circularity goals in the future (Arnoldussen et al., 2017; Economisch instituut van de Bouw, 2015; Government of the Netherlands, 2016; Lucas et al., 2016). Introducing innovation comes with two challenges: procurement of innovation and management of uncertainties related to innovation.

Innovation can be procured through many procurement procedures including Innovation Partnership (Government of the Netherlands, 2012; Arnoldussen et al., 2017; Eadie & Potts, 2016).The experiences with Innovation Partnerships are limited. In 2016 the European Commission added the procedure to the procurement law (Government of the Netherlands, 2012; European Commission, 2014). Since then, in the Dutch construction industry, one project has been completed (De groene droom, 2020) and two projects are ongoing at the moment: Sterke lekdijk (Hoogheemraadschap De Stichting Rijnlanden, 2020) and Innovatiepartnerschap kademuren (Gemeente Amsterdam, 2019), that are procured through an Innovation Partnership procedure. Altho it is not the main objective of this research; the research contributes to the existing knowledge about the Innovation Partnership by exploring practical experiences with the procedure.

The uncertainties of innovation are the main problem this research addresses. Risk management for projects without innovation has been researched and documented before (Project management institute, 2017; Nicholas & Steyn, 2017). Risks are managed through contractual agreements between the contractors and the contracting authorities. Identification of risks is the first step in risk management (Nicholas & Steyn, 2017). During the projects' life cycle, risk can occur and may cause damage to one or multiple parties involved. To be able to accommodate these uncertainties, the parties should agree on how to deal with this situation before it occurs (Nicholas & Steyn, 2017). However, when an innovation is included in a project, unforeseeable uncertainty could cause a problem (Loch et al., 2006, 2008; Rogers, 2003; De Fátima Segger Macri Russo et al., 2013). This research aims to indicate how uncertainties and unforeseen uncertainties related to product innovation procured by an Innovation Partnership should be managed in construction projects.

Relevance

Because the use of an innovation in a project comes with extra uncertainties, contractors and contracting authorities are likely to be risk-averse (Uyarra et al., 2014; Bowers & Khorakian, 2014). Risk aversion influences the innovativeness of contractors and contracting authorities. It is more likely that they will use traditional or known solutions, and only incremental innovations will take place (Rogers, 2003). Radical change is needed to facilitate the transition (Lodder et al., 2017). Thus, to reach radical innovation in the construction industry, innovation-related uncertainties must be dealt with.

1.3. Focus and scope

This research includes several subjects; procurement management, risk management, and innovation management in a Dutch construction project, see figure 1.1. Procurement management covers the Dutch and European procurement law, aanbestedingswet 2012 and EU directive 2014/24/EU respectively.

Innovation management includes the management of all aspects of the innovations that are introduced in a project. The creation of an innovation and the design of the innovation are not part of the scope of this research. Risk management covers the management of uncertainties in projects. As can be seen in figure 1.1, these three topics overlap. Procurement and innovation combine when innovation is included in the tender invitation of the contracting authority. Innovation can be included in several procurement procedures. This research focuses mainly on Innovation Partnership.

Innovation and risk management overlap in the area of management of risks related to innovation. Innovation brings additional uncertainties that have to be managed. Procurement and risk management are connected through the contracts used to execute the projects. The three subjects overlap in the objective of this research; management of uncertainties related to innovation in the context of an Innovation Partnership.

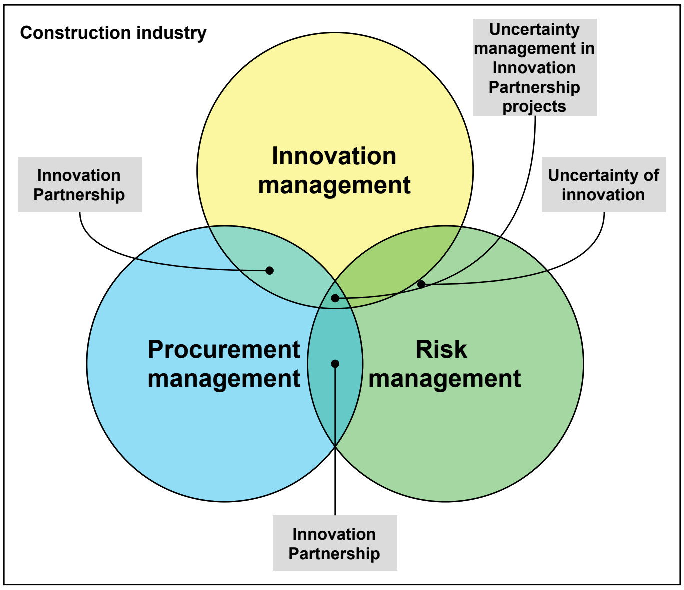

Figure 1.1: Research scope

1.4. Research question and sub questions

This research contains three main subjects: innovation, Innovation Partnership, and risk management. These three subjects form the basis of the main research question:

*How can an **Innovation Partnership** stimulate **innovation** in the construction industry by dealing with **uncertainties** related to product innovation?*

To answer the main question, 5 sub-questions are composed:

1. How does the procurement of innovation facilitate the need for innovation in construction projects?
    (a) What is innovation?
    (b) Why and how are innovations procured in the Netherlands?
2. What uncertainties relate to innovation in construction projects?
3. How does the Innovation Partnership deal with barriers for the implementation of product innovations in construction projects?
    (a) What is the Innovation Partnership?
    (b) What is the difference with other procurement procedures?
    (c) What are recognized barriers for development and implementation of product innovations in construction projects?
4. How does the use of a product innovation in a project affect the way risks and uncertainties related to innovation are managed in a project?
    (a) What types of risks should be managed?
    (b) How is risk management established in different contracts?
5. How, in current practice, are innovations included in construction projects?
    (a) What are experienced barriers to innovate?
    (b) How are unforeseen events managed in practice?
    (c) How is the Innovation Partnership experienced in practice?

1.5. Research methodology

In figure 1.2 an overview is presented of the research methods used for this research. As shown, the study consists of four main parts: Literature review, Practical experiences, analysis of literature and experiences, and a validation of the results. The research is a qualitative type of research with a practical orientation. In practice-oriented research, knowledge and information are provided to contribute to the decision-making to solve a practical problem (Verschuren et al., 2010).

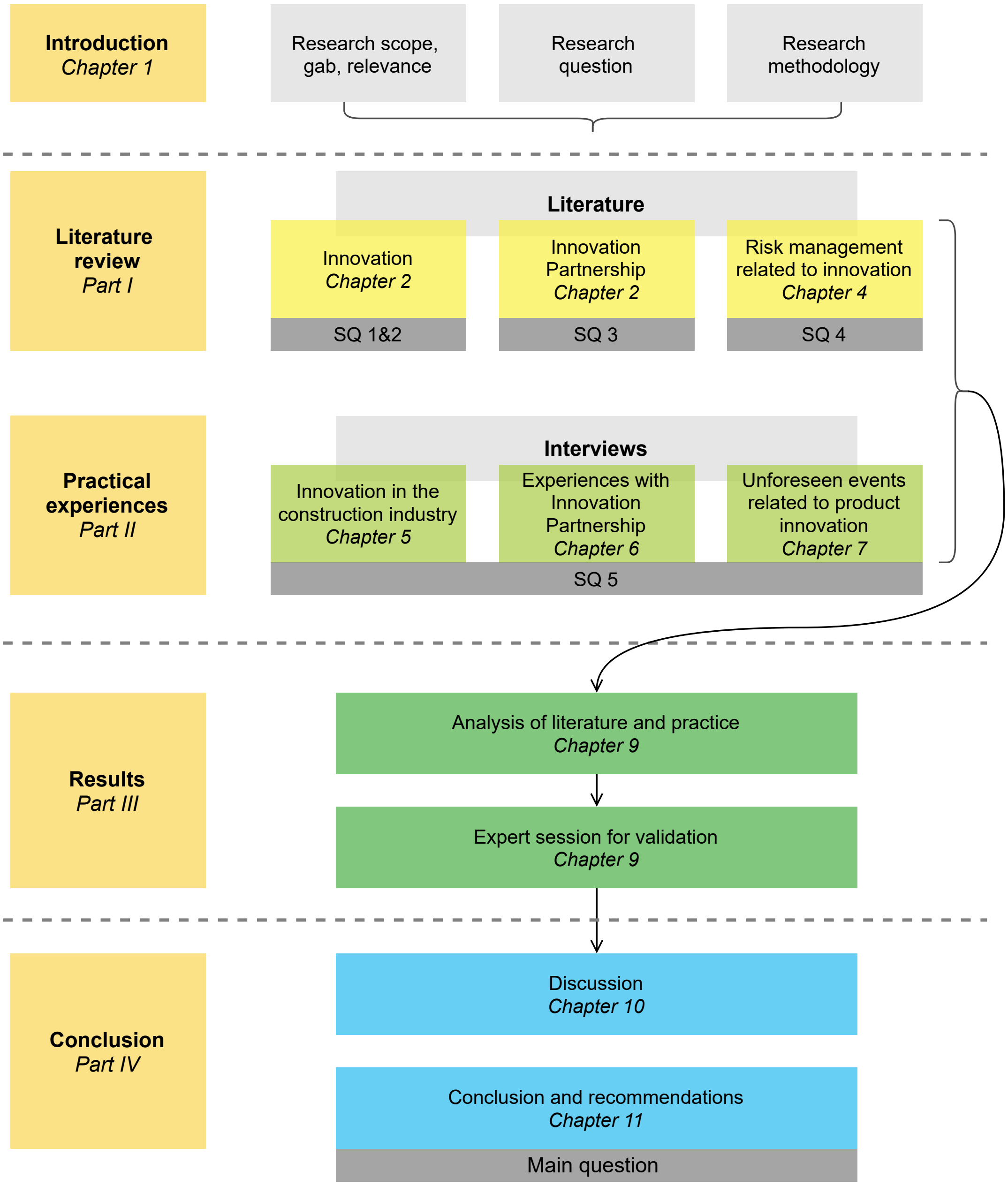

Figure 1.2: Research methodology

1.5.1. Literature review

A literature study is conducted to compile a theoretical understanding of innovation, procurement of innovation, and management of uncertainties of innovation. The literature review cover three main subjects:

- Innovation management;
- Procurement of projects that include innovation through an Innovation Partnership;
- Management of risks related to innovations in construction projects;

First, the literature is used to establish a definition of innovation and identify the urgency for innovation. The definition of innovation used for this research is based on scientific papers, European procurement law, and Dutch procurement law. Second, the research uses European-wide legislation, challenges appearing in the Netherlands, and sector-specific tasks, to establish the urgency of innovation.

Next, the literature is used to formulate a basis on innovation procurement, specifically on Innovation Partnership. Innovation Partnership is a procurement method developed to stimulate innovation. An explanation of the procedure is given, and the difference between Innovation Partnership and other procurement procedures is elaborated. For this part, Dutch and European procurement laws are used, along with reports and papers about innovation procurement.

The third subject of the literature study is risk management. First, risk management, in general, is described to establish a common understanding of why risk management is needed. After which, the research focuses on the risk management of a project with innovation. Risk management in a project including innovation includes risk types, management of different types, risk allocation in various contracts.

1.5.2. Practical experiences

Part two of the research includes practical experiences. The experiences are gathered through semi-structured interviews. This research is practical-oriented and therefore builds on existing knowledge to improve practice (Verschuren et al., 2010). The interviews help to identify what the current practice entails and how it can be improved. The semi-structure nature of the interviews facilitate the freedom for the respondents to elaborate freely on their experiences. At the same time, the semi-structured interview questions form a guide during the interview to make sure all topics are discussed.

For this research, the interviews are used to identify the current innovation barriers in the construction industry, specific experiences with unforeseen events related to innovation, and experiences with Innovation Partnerships. Nine interviews were conducted with experts from the field. Six of the nine respondents are currently involved with projects procured through an Innovation Partnership (interviews 2 to 5, 7, and 8). One of the remaining three finished a project procured by an Innovation Partnership (interview 6). Respondent 9 does not have practical experience with the procedure, but he is familiar with the procedure. The final respondent was unfamiliar with Innovation Partnership, but he has experience with projects where innovation is included. Among the interviewees were contract managers, risk managers, innovation managers, and project managers.

The participants were found through contracts of partners and colleagues of Flux partners. To find the right respondents, criteria were set up to what knowledge a respondent must have and what was nice-to-have. These criteria were sent to the partners and managing consultants to consult their work contacts. The criteria included experience with a project where an innovation was used, knowledge of several procurement procedures and contract forms.

1.5.3. Validation

To validate the outcomes of the interviews, an expert session will be conducted. The perspective of three experts in the area of procurement on the contracting authorities side, tender management on the contractor's side, and contract management was gained through ten statements.

The choice for these experts is based on the main subjects of this research: procurement and risk management for a project including product innovation. The expert on contract manager has a clear vision on risk allocation. The procurement and tender experts represent the two sides of a procurement process; the contracting authority and the contractor.

In appendix C the hand-outs with the statements are shown. After a brief introduction to the research, the experts were asked to indicate to what extent they agreed or disagreed with the statements and explain why. The expert had no prior insight into the content of the statements to prevent prejudice. The validation session was one group session so that the experts could react to each other and discuss their points of view. The statements that had to be reacted upon were based on the results from the interviews. Two statements were related to the need for innovation in the construction industry and the inclusion of innovation in the tender invitation of the contracting authority. Statement 3 to 6 discussed Innovation Partnership and the barriers of innovation, and statements 7a to 9 included risks management in projects that include innovation.

I
Literature

Introduction

As described in section 1.5 this report commences with a literature study. In figure 1.3 the content of the literature study contains an exploration of the need for innovation in the construction industry and the uncertainty of innovation. Procurement is an efficient way to deal with the need for innovation (Arnoldussen et al., 2017; Uyarra et al., 2014) and through risk management, the uncertainties are dealt with (Nicholas & Steyn, 2017; Loch et al., 2008; De Fátima Segger Macri Russo et al., 2013).

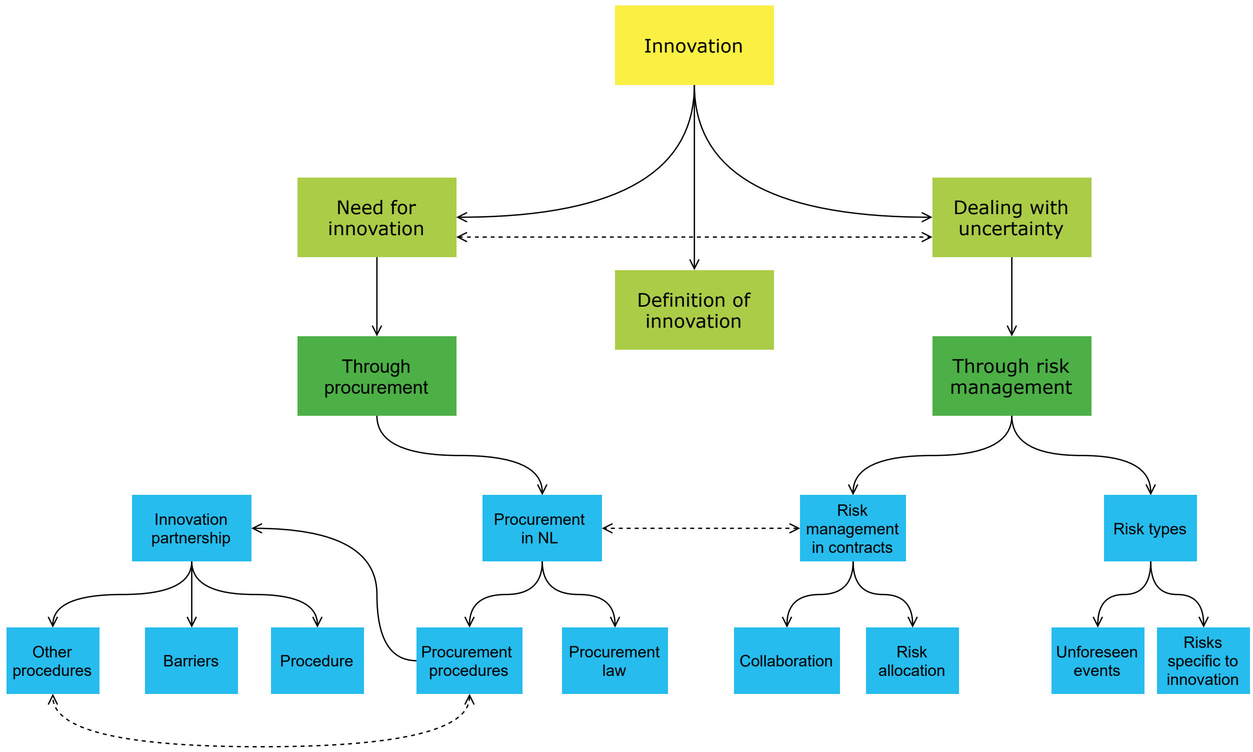

Figure 1.3: Part structure

Chapter 2 first established a definition of innovation used in the research. This definition is composed to ensure the understanding of the word innovation in this research. Then, chapter 2 explores the need for innovation and the uncertainty that comes with innovation. The need for innovation and the uncertainties related to innovation form the foundation of chapter 3 and chapter 4. The aim of chapter 3 to explain and discuss the Innovation Partnership procedure. To conclude the literature study, chapter 4 elaborates on risk management in projects that include innovation.

2. Innovation

There are two main problems with innovation. On the one hand, there is the need for innovation, and on the other hand, there is the uncertainty that comes with innovation. These two parts are highlighted in this research. Before dealing with the uncertainty of innovations, a definition of innovation is formulated, and different types of innovation are discussed.

The need for innovation is dealt with through procurement. Procurement can be seen as a way to stimulate innovation in construction projects (Uyarra et al., 2014). The uncertainty of innovation is dealt with through risk management. When innovation is introduced in a project, risks have to be managed in a way that they cover the management of the extra uncertainty that comes with innovation (Loch et al., 2008; Rogers, 2003).

This chapter creates a basic understanding of innovation (section 2.1), then the need to include innovation in procurement is discussed in section 2.2 & section 2.3. The need for risk management related to innovation is elaborated on in section 2.4 & section 2.5. Figure 2.1 visualizes what will be discussed in this chapter.

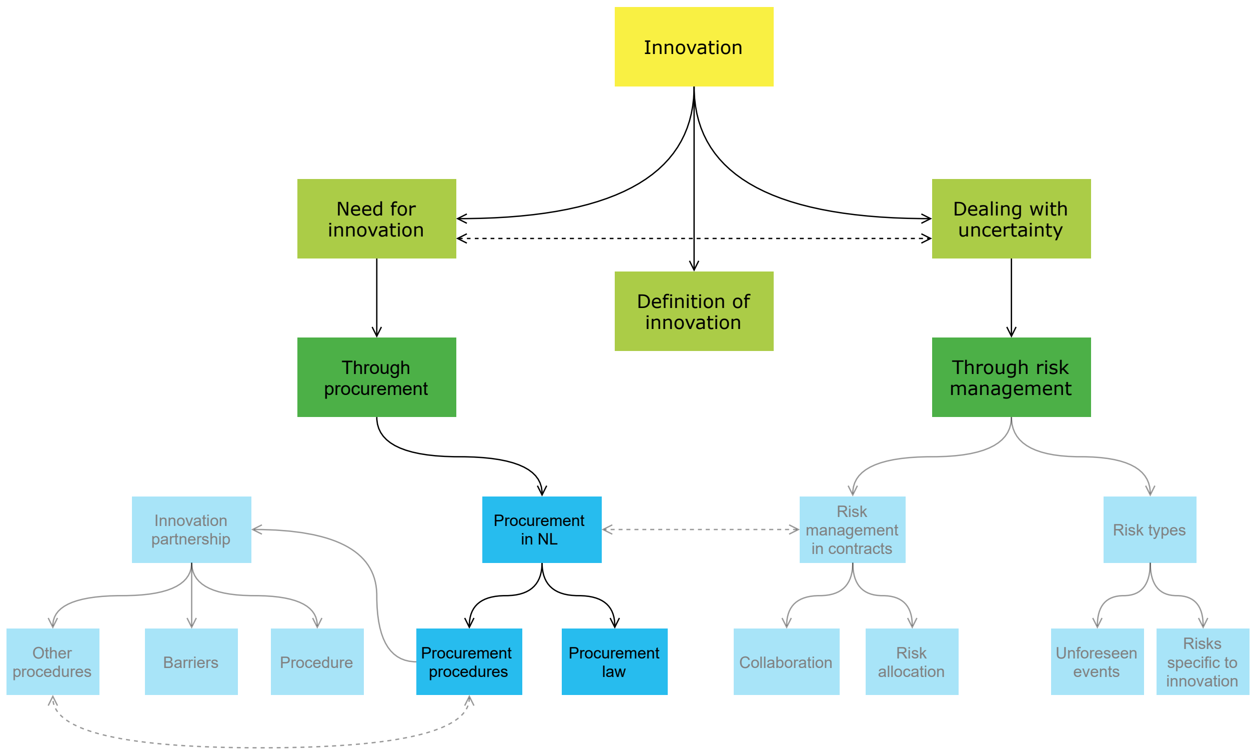

Figure 2.1: Literature: Innovation

2.1. Definition of innovation

This section mentions several definitions of innovation. These definitions are used to formulate a common definition of innovation which will be used for this research. Because of the extensiveness of the literature identifying innovation, a definition of innovation is composed to clarify what is meant by innovation in this research. Also, this section identifies different types of innovations and explains which types of innovation are included in the scope of this research. Finally, this section formulates an answer to sub-question 1a; what is innovation?

2.1.1. Innovation defined by literature

In literature, many different definitions of innovation are used: Blayse & Manley (2004) based on Slaughter (1998) define innovation as: "the actual use of a nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change.". De Fátima Segger Macri Russo et al. (2013), and Nyström et al. (2016) expand the definition with the new product, process, or service increases productivity and improves the quality while minimizing the resources needed. Mortensen & Bloch (2005) define innovation as the implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organizational method in business practices, workplace organization, or external relations. European Commission (2014) defines innovation as "the implementation of a new or significantly improved product, service or process, including but not limited to production, building or construction processes, a new marketing method, or a new organizational method in business practices, workplace organization or external relations among other things to help solve societal challenges or to support the Europe 2020 strategy for smart, sustainable and inclusive growth" (European Commission (2014), art.2.22).

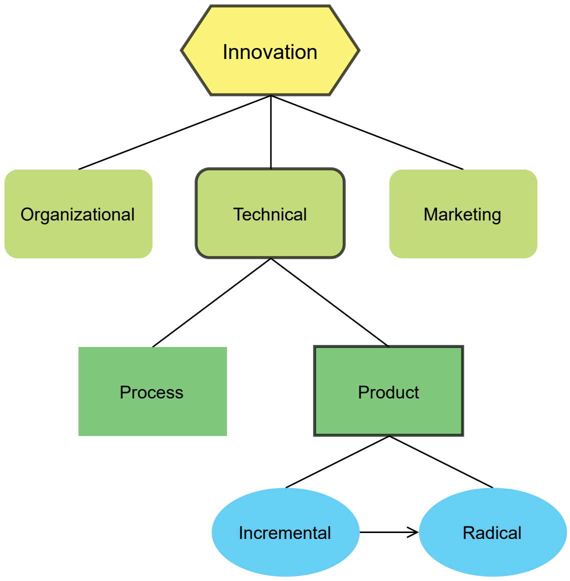

Figure 2.2: Types of innovation

The similarities between the definitions mentioned above are: innovation is "new" (or significantly improved), so it is not, in the desired form, available to the institute developing the innovation. Innovation can be a product, process, or system. Innovation can be organizational, technical, or marketing. Moreover, an innovation improves productivity and quality; it helps solve challenges while minimizing the resources needed. Important to note here are the many different types of innovations. This research will use the following definition of innovation: An innovation is a new or significantly improved product or process for the institute or sector developing innovation, which improves productivity and quality of the project outcome. Figure 2.2 shows the different types of innovation. The next paragraphs go further into detail on these different innovation types.

Types of innovation

European Commission (2014); Mortensen & Bloch (2005) mention organizational, technical, and marketing innovations and Nyström et al. (2016); De Fátima Segger Macri Russo et al. (2013); Blayse & Manley (2004); Slaughter (1998) distinguish a difference between product or process innovations. Organizational, technical, and marketing innovations can all be expressed in process or product innovation.

A marketing innovation is implementing a new marketing method involving significant changes in product design or packaging, product placement, product promotion, or pricing. An organizational innovation is implementing a new organizational method in the firm's business practices, workplace organization, or external relations. Technological innovation is the focus on firms' technological development of new products and new production techniques and their diffusion to other firms (Mortensen & Bloch, 2005). This research includes technical innovations only. Even though organizational innovation is needed within firms to supply innovation in projects, this research's scope includes the innovations implemented in construction projects to achieve the project objectives; those are technical innovations.

process and product innovation

In the explanation of technical innovation, Mortensen & Bloch (2005) mention a difference between process and product innovations. Schilling (2018) defines product innovations as innovations that are included in the output of an organization. In comparison, process innovations are innovations in the way an organization develops its product or services. Mortensen & Bloch (2005) define product innovations as "the introduction of a good or service that is new or significantly improved concerning its characteristic or intended use. These improvements include significant improvement in technical specifications, components and materials, incorporated software, user-friendliness or other functional characteristics"(Mortensen & Bloch, 2005, p.48). They define process innovations as "the implementation of a new or significantly improved production delivery method. Process innovations include significant changes in techniques, equipment, and software" (Mortensen & Bloch, 2005, p.49). Schilling (2018) also states that Process and product innovation often occur in pairs. Either a new process creates the opportunity to develop a new product, or a new product enables the development of a new process.

This research includes publicly procured projects in which innovations are developed and implemented. Only technical product innovations are considered for this research because they require specifications composed by the contracting authority and can be measured alongside a technology readiness ladder (these elements are subjects further on in the report).

Incremental to radical innovations

Product innovations include several sub-types of innovations. Slaughter (1998) mentions five types of product innovations: Incremental innovations, modular innovations, architectural innovations, system innovations, and radical innovations. She identifies incremental innovations to be small changes based on existing knowledge and experience. Radical innovation, on the other end of the spectrum, is "a breakthrough in science or technology that often changes the nature of an industry" (Slaughter, 1998). Modular, architectural, and system innovations are located in the middle between incremental en radical innovations. A modular or component innovation is a significant change to a specific part of a system, but it does not affect the overall configuration of the system (Schilling, 2018). In contrast, an architectural innovation changes the overall design of a system, or the way the components of the system interact with each other (Schilling, 2018). The fifth innovation type Slaughter (1998) mentions is system innovation. System innovations are innovations where multiple independent innovations work together to perform new functions or improve the facility performance as a whole (Slaughter, 1998).

Incremental innovation is much easier to create and is more reliable (and thus, incremental innovation is less uncertain) (Rogers, 2003). For that reason, incremental innovation is more common than radical innovation (Gambatese & Hallowell, 2011). Even though incremental innovation can be small, it causes attention to do it better (Gambatese & Hallowell, 2011). In contrast to modular or system innovation, an exact definition of radical innovation is not given. Schilling (2018) explains a radical innovation to be 'very new' and 'different for other solutions.'. The 'radicalness' of an innovation can be determined by combining newness and how different it is from existing products. Slaughter (1998) presents the introduction of steel as a building material as a radical innovation. The introduction of this innovation resulted in a change of working method, changes in design, and it enabled the opportunities for different designs which were not executable before. A more recent radical innovation is BIM (Building Information Modeling). This system changed the way contractors work together to achieve project goals. Although BIM can be seen as a technical or organizational process innovation, it is an example of a radical innovation. The integrated way of working utilizes the skills and knowledge of suppliers and contractors in the whole life cycle of the project (Elmualim & Gilder, 2014). The transition to implement BIM in every construction project is still ongoing.

An example of incremental innovation is the use of full-body harnesses to ensure safety on the construction site (Slaughter, 1998). These harnesses were an improvement of safety harnesses already available. Here, the incremental improvement was the use of materials similar to mountain climbers gear (Slaughter, 1998).

The examples visualize the difference between radical and incremental innovation. Where radical innovation changes the way of working for a whole sector or industry, incremental innovation more often adjusts the way for working in an organization (Slaughter, 1998). The difference between incremental and radical innovation is also indicated in terms of risks. Because radical innovation exceeds an organization, contractors and suppliers vary in experience and familiarity with the innovation (Schilling, 2018). The more radical an innovation, the more expertise and knowledge is needed to adopt the innovation, the more uncertainty the innovation creates, and the more complex the implementation of the innovation will be for an organization (Rogers, 2003).

It is not easy to indicate what type of innovation a specific innovation is precise. The innovations can be interpreted differently for every person, organization, industry, or country (Schilling, 2018). An example of the difference in perspective is the use of rejuvenation cream for asphalt. Rejuvenation cream is used to extend the life of the asphalt. Rejuvenation cream is an innovation introduced to the construction industry over the last few years. However, rejuvenation cream has been used to renovate wooden furniture (in the form of varnish) for a long time.

Summary

Sub-question 1a; What is innovation? can be answered. Innovation is a new or significantly improved product or process for the institute or sector developing innovation, which improves productivity and quality of the project outcome. For this research, the word innovation indicates technical product innovation unless indicated differently.

2.2. Need for innovation

In the last few years, the demand for innovation in construction projects has increased. This section elaborates on the purpose of the use of innovation. It answers the question of why innovation is so sought-after to indicate the relevance of this research. This section answers question 1b; Why and how are innovations procured in the Netherlands?

2.2.1. Need for innovation in The Netherlands

In the upcoming years, the building industry has to execute many large scale projects in the infrastructure sector (Arnoldussen et al., 2017; Economisch instituut van de Bouw, 2015; Lodder et al., 2017). Arnoldussen et al. (2017) identifies the main tasks for the GWW sector, consisting of the replacement and renovation of the existing infrastructure. To be able to accomplish these tasks, the construction industry has to innovate in multiple areas. Furthermore, new techniques and products have to be developed to meet future requirements and regulations (Arnoldussen et al., 2017).

The report "A circular economy in the Netherlands by 2050" (Government of the Netherlands, 2016) summarizes the Dutch circularity goal for 2050: the utilization of raw materials in existing supply chains is improved to a high-quality manner if new raw materials are necessary, they are sustainably produced, renewable and generally available, and new production methods are developed and new products to use as raw material are designed. The sustainable development goals for 2030 (Lucas et al., 2016) add to that (SDG 9, target 9.4): "By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action following their respective capabilities". Although with the knowledge, expertise and products currently available on the market, these goals will not be reached by 2030.

2.2.2. Need for innovation in the construction sector

All significant issues mentioned in the above paragraph indicate the demand for innovation on a national level. To improve nationally and comply with future regulations, every public project should contribute to the solution. The construction sector requires a transition in the fields of sustainability, climate change and circularity (Bras & Remmerts, 2018). The meaning behind the word "transition" is that the complex systems need to develop towards an optimum (Lodder et al., 2017). A transition agenda is composed by the Dutch government to achieve a circular construction economy in 2050 (Rijksoverheid, 2018). The problems with transition lay in the traditional way of thinking. Existing systems and products are developed further instead of proposing new systems and products (Lodder et al., 2017). In other words, the problem is the proposition of radical changes. The Innovation Partnership procedure can stimulate a radical way of thinking because the procedure can facilitate a technology-push innovation process since it can offer a big solution space (Bras & Remmerts, 2018), section 2.3.2 elaborates further on this.

Besides the sustainability and circularity goals and the need for replacement and renovation of the existing infrastructure, contracting authorities and contractors can also benefit from innovation. On an operational level, contracting authorities and contractors can, with the use of innovation, reduce costs, establish competitive advantage, and increase quality and productivity (Gambatese & Hallowell, 2011).

2.3. Procurement of projects that include innovation

The need for innovation is clear, but how is an innovation introduced in a project? This section elaborates on the role of procurement procedures and the role of the government in including innovation in construction projects. First, Dutch and European procurement laws are explained in subsection 2.3.1. Then, how to include innovation in a procurement procedure is described in subsection 2.3.2 and subsection 2.3.3 different procurement procedures are mentioned.

2.3.1. European and Dutch procurement law

To treat every business in Europe equally, the European procurement law lays out a set of regulations for public procurement of works, supplies and services (European Commission, 2014). The regulations are combined in DIRECTIVE 2014/24/EU of the European Parliament and the council. Based on the European directive, the Netherlands also has their own national procurement law: Aanbestedingswet 2012.

Definitions

European procurement law is set out in European Directive 2014/24/EU (European Commission, 2014). It defines public procurement as *"the acquisition by means of a public contract of works, supplies of services by one or more contracting authorities from economic operates chosen by those contracting authorities, whether or not the works, supplies or services are intended for public purpose"* (European Commission, 2014, art. 1, sub. 2). In essence, this means, public procurement is the process of a contracting authority purchasing works, supplies or services from parties that have these works, supplies or services available. The context of this research includes purchasing public work contracts and the submission of tenders made by contractors. European Commission (2014) defines 'contracting authority' as *"a state, regional or local authority, bodies governed by public law or associations formed by one or more such authorities or one or more such bodies governed by public law"* (art. 2, sub 1.2). Contracting authorities in the Netherlands include (non-exhaustive list): Rijkswaterstaat, Municipalities, Waterschappen, and Provinces. The Dutch procurement law (Government of the Netherlands, 2012) identifies contractor as "any company the offers the execution of the works on the market" (art. 1, sub 1).

The definition of a public works contract is a public contract which includes the execution and/or design of a work or a contract that includes the realization of work meeting the requirement set by the contracting authority, who has a decisive influence on the design and type of the work (European Commission, 2014, art. 2, sub 6a). A 'work' is *"the outcome of building or civil engineering works taken as a whole which is sufficient in itself to fulfil an economic of technical function"* (European Commission, 2014, art 2, sub 7). These definitions are similar to the definitions laid out in the Dutch procurement law (Government of the Netherlands, 2012, art. 1).

Procurement process

A project has to be publicly procured when the project exceeds the tender threshold of €5.350.000,- for public works contracts, €139.000,- for supply and service contracts awarded by a central government, and €214.00 for supply and service contract awarded by a sub-central government (European Commission, 2014). Therefore, if a contracting authority wants to outsource a project exceeding this amount, they have to follow the European directive on public procurement. In general, a public procurement process consists of three main stages: Preparations of the tender, the tender procedure, and the execution of the project. Figure 2.3 Visualizes a general procurement process based on steps retrieved from the Aanbestedingswet 2012 and PIANOo.

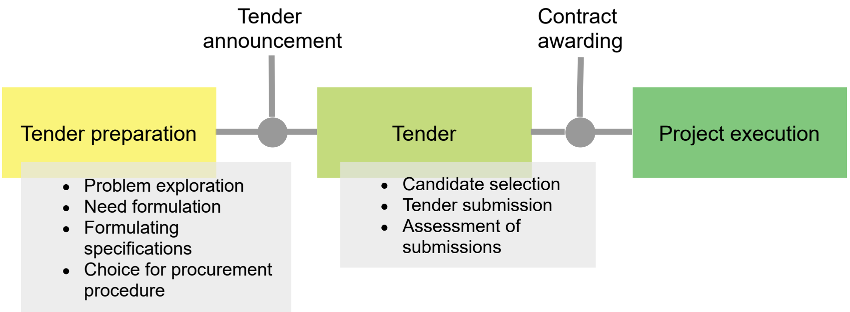

Figure 2.3: General procurement process

Tender preparation

The first stage, tender preparation, contains, among other things, the exploration of the problem. Here, the contracting authority decides to either outsource the project, execute it themselves, or combine both options. Also, part of the tender preparation is the choice for procurement procedure, formulation of specification and establishing the needs. To exploit this, PIANOo (n.d.-b) suggests the knowledge of the market is needed. Through a market consultation, the wanted knowledge can be retrieved. After receiving all the necessary knowledge, the contracting authority chooses a procurement procedure and publicly announces the tender.

In the tender preparations, the contracting authority specifies the requirements for the tender invitation. These specifications can either be performance-based, functional, or technical (Government of the Netherlands, 2012). Performance-based and functional specifications leave more space for interpretation and thus leave options for innovative ideas than technical requirements.

Tender

During the second stage, the tender itself, the contracting authority selects candidates (this is only for 'closed' procurement procedures. See section 2.3.3 for an elaboration on what procedures use a selection of candidates). After the selection of candidates, based on exclusion grounds, the candidates submit their tender. The tenders are assessed, and the contracting authority awards the contract to the best submission based on predefined award criteria.

Project execution

After the contract is awarded, the third stage starts, the execution of the project. At this point, the procurement process has ended. The contracting authority Is not obligated to award the contract when none of the submissions meets their expectations. However, if the contract is not awarded, the contracting authority has to restart the whole procurement process if they still want to outsource the project (Chao-Duivis et al., 2018).

2.3.2. Including innovation in procurement

"Public procurement is increasingly viewed as having the potential to drive innovation"(Uyarra et al., 2014, p.631). European Commission (2018) identifies the procurement of innovation as buying the innovation process (the process in which an innovation is developed) and buying the outcome of the innovation process. Eadie & Potts (2016) describe the process of procurement of an innovation. The process starts with identifying a "grand challenge", followed by transforming this challenge into functional and technical requirements (Eadie & Potts, 2016). Then, the tendering process takes place where the problem is formulated and brought to the market, which, in turn, can formulate a formal bid. The contracting authority then assesses the tender and awards the contracts. The delivery process concludes the public procurement of an innovation, including product development, product production, and the final delivery to the contracting authority. For this research, "the public procurement of a project including innovation is" defined as: the procurement of a project in which the contracting authority requests an innovation to be implemented or a contracting authority proposes an innovation in their tender.

Also, for contracting authorities, it is not always possible to innovate on their own. For example, it could be that the objective of the project/innovation exceeds the knowledge and expertise of the contracting authority (Schilling, 2018). Therefore, contracting authorities can decide to find the right expertise and knowledge through market parties by inviting them to tender.

The government's role in innovation

Mazzucato (2018) states that the government has been the source of the most radical types of innovations by funding risky research. the private sector in their turn are less entrepreneurial. Therefore, the most uncertain investments are made by the government (Mazzucato, 2018). This can be explained by the the unique capabilities the government has due to its size. Government investments in an early stage of technological development in the public sector can create new products and markets (Mazzucato, 2018). The government needs to and can take risks that the private sector is not willing to take (Mazzucato, 2018).

In the case of a construction project, the government presents different roles: The client owner, the future owner and the licensing authority (Koops, 2017). The client owner represents the contracting authority in a project. The future owner is the maintainer and operator of the project after completion, and the licensing authority makes sure all elements of the projects comply with the rules and regulations.

Technology-push and Demand-pull

When innovation is included in a project, either the contracting authority requested an innovation in their tender invitation (demand-pull), or the contractor proposed the innovation (technology-push) (Rothwell, 1994).

Technology-push

Technology-push was the first generation of innovation processes Rothwell (1994). This approach starts with basic science (or scientific discovery (Dodgson et al., 2008)) followed by the design of a new product that is manufactured, marketed, and finally sold (Rothwell, 1994). See figure 2.4. This approach was a legacy of World War Two, where scientific discoveries were transformed into technological innovations (for example, nuclear bombs) (Dodgson et al., 2008). Where the applicability of this approach during WOII was suitable, it was soon discovered that the technology-push process did not facilitate 'real-world' products (Schilling, 2018). In the 1960s, the second generation of innovation process was introduced.

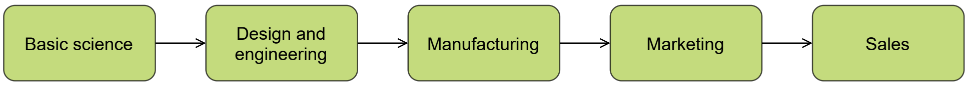

Figure 2.4: First generation innovation process; Technology-push (Rothwell, 1994)

Demand-pull

The second generation innovation process is "demand-pull" (Rothwell, 1994). In this innovation process, innovations are derived from a market need (Dodgson et al., 2008). Then, innovations are developed following the customers' suggestions and comments (Schilling, 2018). Finally, the market demand is followed by the development of an innovation, marketing, and sales, depicted in figure 2.5 (Rothwell, 1994).

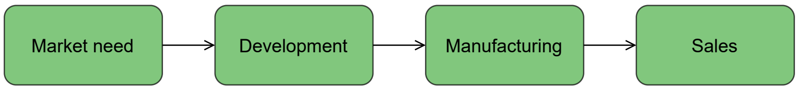

Figure 2.5: Second generation innovation process; Demand-pull (Rothwell, 1994)

Procurement procedures

When the contracting authority includes their request for an innovation in their tender invitation, it translates to a demand-pull situation. Here, the contracting authority's innovation request represents the market need.

It has been indicated that a demand-pull innovation process triggers most likely more incremental innovations (Nemet, 2009). In contrast, a technology-push process facilitates more radical innovation because they are not bound to the limitations of a client's request. Considering the innovation processes and the procurement procedures, the nature of the innovation request in the tender invitation influences the radicalness of the innovation.

Technology readiness level

An aspect of innovation that influences the way they are included in a project is the innovation's readiness. The readiness of innovation is measured alongside the technology readiness level ladder (TRL-ladder). The TRL levels indicate the readiness of a product and thus the amount of development still needed before it is fully ready on the market. Mai (2017) explains the meaning of the levels:

1. Basic principles observed and reported
2. Technology concept formulated
3. Analytical and experimental critical function and/or characteristic proof of concept
4. Component validation in a laboratory environment
5. Component validation in a relevant environment
6. Subsystem model or prototype demonstration in a relevant environment
7. System prototype demonstration in a relevant environment
8. Actual system completed through tests and demonstration
9. Actual system proven through successful mission operations

The lower the starting level of the innovation, the more uncertainty the innovation brings to the project. The ladder presented above is developed by NASA (Mai, 2017). After the completion of TRL 8, the innovation can be implemented in the project. The assessment of the TRL identifies how far the innovation is developed and what actions still need to be taken (Karstens, 2018).

2.3.3. Procurement procedures in The Netherlands

5 of the 10 (mentioned in Government of the Netherlands (2012)) procurement procedures are mentioned in this subsection. The procedures are described briefly to distinguish the main differences between the Innovation Partnership and the other procedures. The selection is based on the most used procedures and the Innovation Partnership since the addition of Innovation Partnership in the Dutch procurement law (2016 - 2020)(Tenderned, 2021). The procedures which will be discussed are: Restricted or open procedure, Competition with negotiations, Pre-commercial procurement, Competitive dialogue, and Innovation Partnership. The procurement procedures are mentioned here to indicate the which procedures can be chosen by the contracting authority.

Innovation Partnership is the newest addition to the EU directive and the Dutch procurement law 2012, in 2016. An Innovation Partnership aims to facilitate the implementation of innovation in construction projects. Since Innovation Partnership is the newest addition to the procurement law, this research focuses on this procedure. As explained in chapter 1 the research aims to indicate how an Innovation Partnership stimulates by dealing with the uncertainties of innovation.

Figure 2.6 visualizes the steps in every procedure. The formulation of the tender and the tender phase are in every procedure the same. These steps include the exploration, tender invitation, and candidate selection based on exclusion grounds. The main difference between the procedures shows in the assessment phase of the procedures.

Restricted/open procedure

In a restricted or open procurement procedure, the contracting authority proposes their problem solution or specified project objective. With an open procedure, every market party is free to enter in the tender. With a restricted procedure, the contracting authority has the option to set minimum requirements for market parties to enter into the tender. After submitting the proposal from the market parties, the contracting authority chooses one based on the beforehand agreed upon selection criteria. In a restricted or open procedure, the contracting authority has a clear idea of the project and only looks for the right market party to execute their idea.

Competitive procedure with negotiations

This procedure offers the contracting authority more flexibility in awarding the contracts when an existing solution is not available on the market (European Commission, 2018). In this procedure, the contracting authority can set minimum requirements for market parties to enter the tender. After the first submission of the tender from the market parties, there is a possibility to negotiate or discuss the tender between the contracting authority and the contractor. In the negotiations, only the nature of the proposed solution can be discussed. The requirements set in the tender invitation are not negotiable.

Pre-commercial procurement (SBIR)

In Pre-commercial procurement (PCP), the contracting authority chooses not to reserve the R&D results exclusively for its own use. PCP is a procurement procedure in which the R&D services are procured. This procedure does not include the deployment of commercial volumes of the end-product.

PCP in the Netherlands is known as SBIR (Small Business Innovation Research)(PIANOo, 2020b). The procedure includes the ask of the contracting authority for an innovative solution to their proposed problem. In an SBIR procedure relates to the research and development phase before the commercializing of the innovation. When the contracting authority decides to procure the innovation developed during the SBIR procedure, in most cases, the contracting authority must start a new procurement procedure to do so (European Commission, 2018). "The contract can include the purchase of the innovation as long as the value of the services exceeds that of the products covered by the contract" (European Commission, 2018).

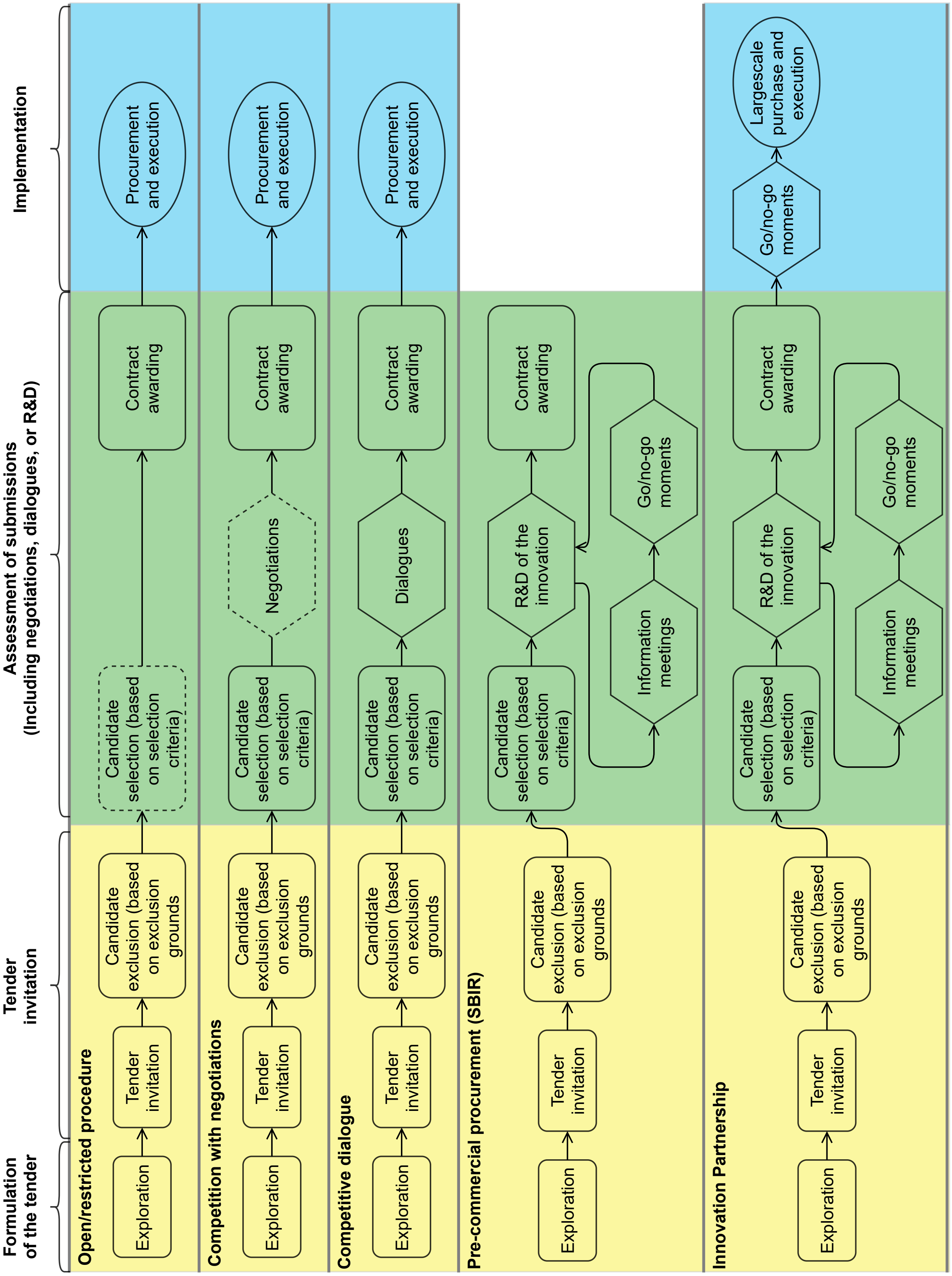

Figure 2.6: Process of the procurement procedures

European Commission (2007) explains that with PCP, the contracting authority shares the risks and benefits with the parties involved in the Pre-commercial procurement such that both parties have an incentive to pursue in the procurement of the innovative solution. The common objective ensures that the arrangement between the two is beneficial for both.

Competitive dialogue

Competitive dialogue is a two rounded procedure in which the contracting authority writes their need in a descriptive document. This document contains the minimum requirements and defines the contract award criteria based on the best price ratio (European Commission, 2018). The innovation potential of this procedure comes forward in the descriptive nature of the need from the contracting authority. The participants can propose a wide range of solutions to the contracting authorities needs (European Commission, 2018).

Figure 2.6 shows the timeline of the different procurement procedures and how they relate to each other. Per procedure, it is implicated what the steps of the process are. The figure is not a complete representation of all the procedures. The steps shown in the figure are simplified to be able to compare.

The Innovation Partnership

As can be seen in figure 2.6, the first few steps are the same for all procedures. However, the content of the documents provided in the steps might differ (e.g. In a competitive dialogue, the tender invitation is less extensive than for a competition with negotiations). PCP and Innovation Partnership are the two procurement procedures that include research and development. Therefore, they provide the opportunity to develop an innovative solution in consultation with the contracting authority. The main difference between PCP and Innovation Partnership is that an Innovation Partnership includes the procurement and development of the innovation in the same procedure. In contrast, in a PCP procedure, the procurement of the developed innovation has to be included in a new procurement procedure. Chapter 3 goes further into detail on the Innovation Partnership.

2.3.4. Summary

Sections 2.2 and 2.3 formulate and answer to the sub-question 1b; Why and how are innovations procured in the Netherlands?

Innovation is introduced in projects through procurement because there is a need for innovation in the Netherlands and the construction industry. The need for innovation results from the need for replacement and renovation of existing infrastructure, the Dutch circularity goals for 2050 and the sustainability goals for 2030. To achieve these goals, a transition is needed. The traditional way of thinking within firms must be replaced with the proposing of radical ideas. Furthermore, it benefits contractors and contracting authorities through cost reductions, the establishment of competitive advantage, and an increase in quality and productivity.

How innovations are procured is described in section 2.3. Innovations are publicly procured following the Dutch and European procurement law when the project exceeds the tender threshold. Innovating through procurement facilitates for the contracting authority as they can find the missing expertise and knowledge in an external party. If the contracting authority requests innovation in their tender invitation, they enter into a demand-pull process. In a demand-pull innovation process where innovations are derived from a market need. In contrast, in a technology-push innovation process, innovation is derived from basic science. Studies show that technology-push-based innovations are more radical, whereas demand-pull innovations tend to be more incremental.

2.4. Need for risk management with innovation

When, in a project, the objectives are reached through the implementation of an innovation, the project by definition contains more uncertainty than a project where there is no need to innovate (Procurement of innovation platform, 2014). How big the difference in uncertainty is, is defined by the nature of the innovation. For the purpose of this research, this section establishes the need for risk management with project that include innovation. Valle & Vázquez-Bustelo (2009) describes a radical innovation to include a high level of risks because there is a high level of complexity in new product development. Rogers (2003) argues that the more radical the innovation, the more uncertainty it creates, based on the amount of knowledge present within the organization. In contrast, incremental innovations do not create much more uncertainty than a proven product since they do not require as much technical expertise needed to implement (Rogers, 2003, p.426).

Stosic et al. (2017) defines the objective of risk management to ensure that no risks occur during the execution of the project. Without risk management, the failure probability of the project increases, demanding additional resources (Stosic et al., 2017).

2.5. A risk management method

This section establishes a basis for a risk management method and the section discusses the origin of risks to reflect on in the subsequent chapters of this report. In their book, Bakker & de Kleijn (2018) define project risk as "uncertainties that matter". This practical and straightforward definition covers two essential concepts: risks are about uncertainties, however only the uncertainties which threaten the outcome of the project (Bakker & de Kleijn, 2018).

Figure 2.7 indicates several types of uncertainties and risks. In essence, risk management deals with the unexpected. Even though a risk management plan covers many risk hazards and consequences, it can never cover all risks. Therefore it is important to "expect that something surely will go wrong" and to be ready to find ways to deal with it as it emerges (Nicholas & Steyn, 2017).

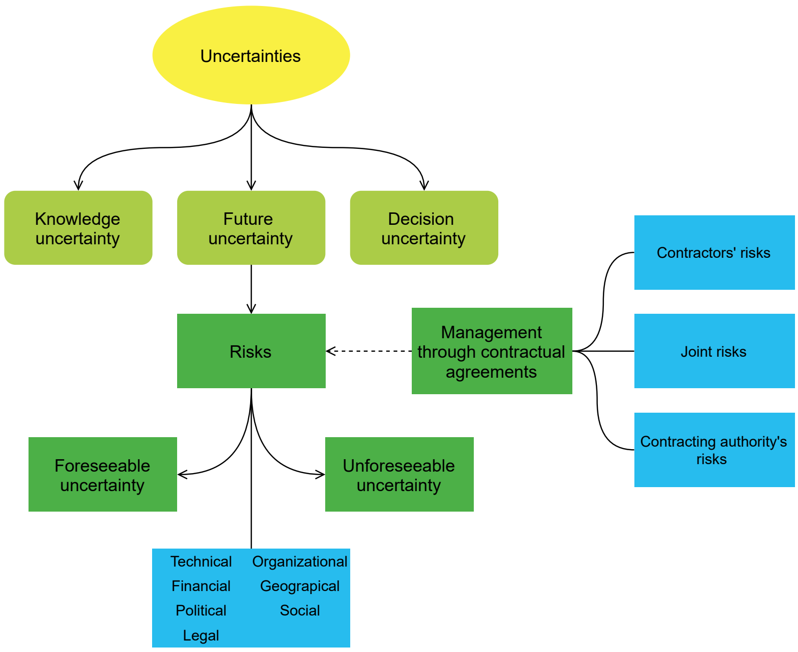

Figure 2.7: Risk management scheme

2.5.1. Uncertainties

In addition, CROW (2010) mentions three kinds of uncertainties; future uncertainty, decision uncertainty, and knowledge uncertainty. Decision uncertainty covers uncertainties related to choices that have to be made by the contracting authority. The contractor must deal with decision uncertainties as long as the contracting authority has not chosen a solution. Knowledge uncertainty comes from the lack of knowledge for an accurate design, situation description of the system. To enhance knowledge uncertainty, CROW (2010) introduces probable values. The unknown variables are defined in ranges to include all possible values. The third uncertainty CROW (2010) mentions is future uncertainty. Future uncertainty introduces risks; 'unwanted events which can occur in the future.

2.5.2. Risks

Project risks involve two parts, a likelihood and an impact (Nicholas & Steyn, 2017). The likelihood is the probability of the occurrence of the risk. The impact of the risk is the consequence the risk has when it occurs. If either one of these factors is significant, mitigating measures are put into place to reduce the likelihood of the occurrence of the risk or reduce the impact of the risk when it occurs. Thus, the risks are reduced by managing the likelihood or impact of the risk. Opportunities are also considered risks (e.g. additional rewards, or savings). However, in most cases, risk management focuses on the risks which can cause failure (Nicholas & Steyn, 2017).

2.5.3. Management of risks

Nicholas & Steyn (2017); Stosic et al. (2017); Project Management Institute (2009); Bowers & Khorakian (2014) describe the process of risks management, see figure 2.8. First, the project risks are identified. Risk identification contributes to the awareness of the possibility of something happening. If a person is aware of the risks, they can be managed. Following risk identification, the identified risks are assessed. In other words, the risks are assigned their likelihood, impact, consequences and level op priority. Then, the risk owner plans risk responses. They can either transfer the risk to another party, avoid the risk, reduce the likelihood or impact of the risk, make a contingency planning, or accept the risk (Project Management Institute, 2009; Nicholas & Steyn, 2017). The choice for strategy depends on the level of impact or likelihood a risk has. The identified and assessed risks are logged in a risks register, which is shared between the involved parties. This register is a dynamic document, the risks are monitored and controlled throughout the project, and if needed, more risks are identified, or risks are reassessed.

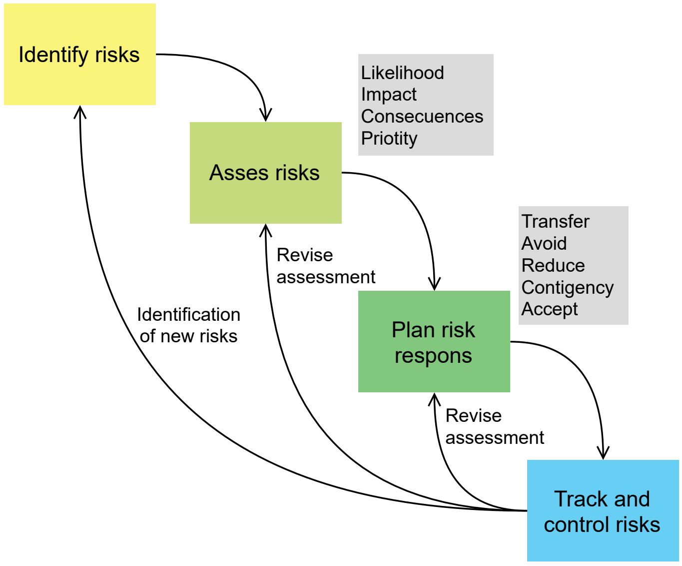

Figure 2.8: Risk management method, based on Nicholas & Steyn (2017)

Risk responds

After identification and assessment of the risks, a risk response is planned. A choice can be made between: transfer the risk, avoid the risk, mitigate the risk, accept the risk, or make a contingency plan (Nicholas & Steyn, 2017).

Transferring the risk relates to the possibility to transfer the risk to another party. Risk transfer methods include: contractual incentives, warranties, penalties or insurance (Nicholas & Steyn, 2017; Project management institute, 2017). By ensuring the risk, it is transferred to an external party. Risks can be transferred to another party that mostly involves payment or risk premium. Risks follow from uncertainties. By hiring subcontractors that specialize in that uncertainty, those risks can be eliminated (Nicholas & Steyn, 2017). The contract type is, in essence, the main way to transfer risks, in the form of risk allocation (Nicholas & Steyn, 2017).

Risks are **avoided** when the project team eliminates the threat or protects themselves from the impact (Project management institute, 2017). Measures to avoid risks are: increase of supervision, elimination of risky activities, decrease system complexity, alternation of technical and/or functional requirements, or change in project organization (Nicholas & Steyn, 2017). (Project management institute, 2017) adds to that, a change in project strategy or reducing the scope. Risk avoidance often entails numerous additional management systems, which, in their turn, could increase project complexity and therefore might introduce new risk sources (Nicholas & Steyn, 2017).

Mitigation of risks means taking action to reduce the probability of occurrence or to reduce the impact of the risk when it occurs (Project management institute, 2017; Nicholas & Steyn, 2017). Risks can be mitigated, for example, through a decrease in project complexity, more extensive testing (Nicholas & Steyn, 2017).

By **accepting** the risk, the threat is acknowledged, but no action is taken (Project management institute, 2017). This response is suitable for low-impact and low-probability risks. However, It might also be that it is not possible or not cost-effective to act on the threat (Project management institute, 2017). Nicholas & Steyn (2017) stated that accepting the risk is an appropriate response if the costs of acting on the risk (avoid, reduce, transfer) exceeds the benefits of the action.

Risk responses can result in secondary and residual risk. Secondary risks are risks introduced by the risk response (Nicholas & Steyn, 2017). Residual risk is the risk that remains after the risk response is planned (Project management institute, 2017). Depending on the risk response, residual risk is eliminated.

An Innovation Partnership introduces another type of risk response: the **go/no-go moments**. Go/ no-go moments allow the contractor and the contracting authority to discuss their concerns, validate the progress of the innovation, and discuss the proceedings. This moment can also function as termination of the contract during the research and development of the innovation when the innovation is not reachable with the agreed-upon price and performance (PIANOo, 2016).

Track and control

Monitoring the risks is especially important in projects where innovation is introduced (Stosic et al., 2017). Because the uncertainty of the product reduces throughout the duration, new risks can be identified (Stosic et al., 2017).

2.6. Summary

The second part of the chapter answered sub-question 2: What type of uncertainties relate to innovation in construction projects? These are: future uncertainties. Future uncertainty translates into risks (CROW, 2010). Two types of future uncertainties exist: foreseeable uncertainty and unforeseeable uncertainty (Loch et al., 2008). Foreseeable uncertainty is dealt with through risk management by identifying, assessing, and allocating the risk (Nicholas & Steyn, 2017). On the other hand, because of the novelty of innovation, innovation comes with more unforeseeable uncertainty (Rogers, 2003; Schilling, 2018).

3. The Innovation Partnership

The Innovation Partnership is the main focus of this research. The Innovation Partnership is considered the newest procurement procedure added to the Procurement Law in 2016. Since then, three Innovation Partnership projects have been initiated in the Dutch construction industry, from which one is finished. These three projects are: "Innovationpartnerschap kademuren Amsterdam" - Renovation and replacement of quay walls in Amsterdam (Gemeente Amsterdam, 2019), "Sterke Lekdijk" - reinforcement of dikes along the Lek between Schoonhoven and Amerongen (Hoogheemraadschap De Stichting Rijnlanden, 2020), and the third project, is completed, "de groene droom" - realization of two climate neutral school buildings in Hof van Twente (De groene droom, 2020). Because the experience with the Innovation Partnership is limited, this chapter explains the procedure, and elaborates on the benefits of the procedure.

This chapter first elaborates extensively on the procedure in section 3.1. Section 3.3 focuses on the barriers to innovation in the sector and how the Innovation Partnership be a solution to the barriers. Figure 3.1 visualizes what will be discussed in this chapter. To conclude, the chapter answers sub-question 3; How does Innovation Partnership deal with barriers for the implementation of product innovations in the construction sector?

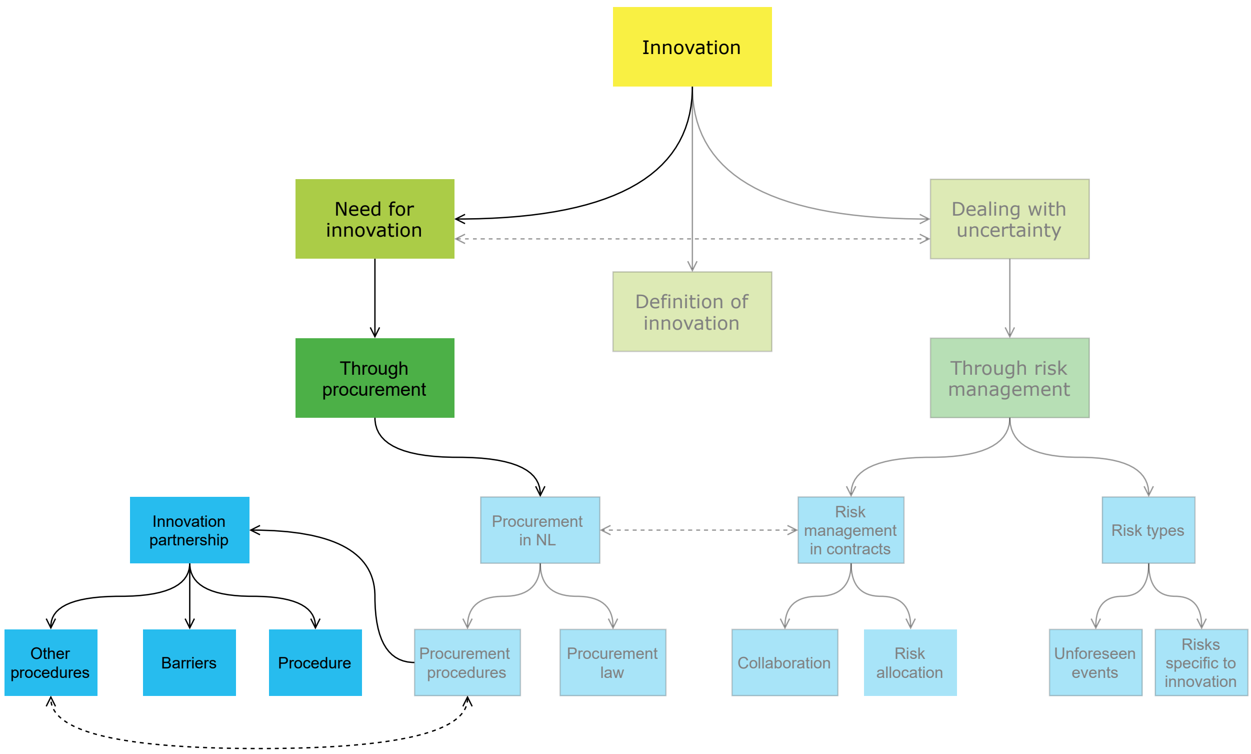

Figure 3.1: Literature: Innovation Partnership

3.1. The procedure: 'the Innovation Partnership'

The Innovation Partnership is designed to facilitate innovation development (PIANOo, 2020a). The procedure is designed in such a way that the intended innovation is developed during the research and development phase in close collaboration between the contractor and the contracting authority. In this section, first, the background of Innovation Partnership is elaborated upon. After this, the next section discusses the procedure. This section aims to answer sub-question 3a; What is Innovation Partnership?

Background

Chapter 2 mentions several procurement procedures. A significant difference between Innovation Partnership and the other procedures is the development of the required innovation in the R&D phase. Innovation Partnership includes research and development in the procurement process (PIANOo, 2020a). The procedure is created to facilitate the large scale purchase of the, during the Innovation Partnership developed, innovation without the interference of a separate procurement procedure (which is the case in a pre-commercial procurement procedure)(State Generaal, 2015).

As is described in (State Generaal, 2015, p.45), the aim of Innovation Partnership is: "the development of innovative products, services or works and the subsequent procurement of the developed innovative product, service, or work, on the condition that it meets the quality and financial requirements which are agreed on by the contracting authority and the partners". This means that the procedure facilitated the development of all promising innovations for the scope.

Procedure

In this section, the procedure of an Innovation Partnership is explained. Figure 3.2 visualizes the steps in the procedure. Some steps in the figure depend on the level of innovativeness and specification of the tender invitation. Therefore, the model only clarifies and shows the connections between the contractor and contracting authority.

PIANOo (2016) describes the steps to be taken in an Innovation Partnership procedure from the contracting authority's point of view. They identified five main steps:

1. Formulation of the tender
2. Procurement process
3. Competition
4. Research and development
5. Implementation phase (in Dutch: Commerciële fase)

Figure 3.2 represents the steps to be taken for both the contractor and the contracting authority based on PIANOo (2016). The figure does not mention the competition phase explicitly because the competition phase is integrated with the procurement and the research and development phase.

Step one is the formulation of the tender invitation. In this step, the contracting authority defines the scope, and sets up selection criteria for potential contractors. Also, the contracting authority conducts a study to examine if the intended scope meets the interest of other potentatial parties. Subsequestly the contracting authority composes a tender invitation.

The second step of the procurement process is the formulation of the tender documents. This includes:

- Selection criteria
- Award criteria
- Intellectual property
- Financial estimations
- Achievements per phase
- Termination
- Role distribution
- Risk allocation
- If there are multiple contractors are chosen; knowledge exchange
- Confidential information.

After this, the third step involves the competition phase. In this phase is the potential contractors submit their tenders. The extensiveness of the submission depends on the tender invitation. First, the contracting authority assesses the submissions and excluded participants based on exclusion grounds. Then, the contracting authority selects a specific number of contractors with which they continue the negations phase. At the end of the negotiations, the selected contractors write their final submission, after which the contracting authority chooses the final participants.

Then, the research and development phase starts. This phase is divided into one or several parts, which can deviate in every Innovation Partnership. What development steps have to be taken depends on the TRL-level requested for the tender invitation. Possible parts are:

- Feasibility of the design
- Proof of concept
- Testing
- Pilot projects
- Certifying

In the complete overview of the procedure in appendix 6 the TRL-ladder (Mai, 2017) is included and linked to the R&D steps mentioned above. The procedure is designed in such a way that at the end of every R&D step, the contracting authority may decide to continue of not continue with a certain candidate during the go/no-go moments. At these moments, the contractor also has the possibility to address concerns and terminate the project. This means that there is continuous close collaboration between the contractor and the contracting authorities. By doing so, all parties involved have a clear idea if the innovation complies with specific requirements.

Termination of the contract is possible in this phase either caused by:

- Technological developments of innovations outside of the contract
- Afterwards appearing of no feasibility of the innovation for the maximal price

The final phase in an Innovation Partnership is the implementation phase. In this phase, the large scale procurement of the innovation takes place, and the project is executed.

Phase of the project	**Phase 1; Formulation of the tender**	**Phase 2; Tender phase**	**Phase 3; Research and development**	**Phase 4; Implementation**
Contracting authority	• Problem formulation • Market consultation • Choice of procurement procedure	• Tender invitation • Exclusion of candidates based on selection criteria	• Selection of participants for the research and development phase • Go/no-go moments • Final contract awarding • Contract for execution	• Realisation of the project • Implementation of the innovation
Contractor	• Explore interest in the project	• (optional) Formation of consortium • Formulate tender • Submit tender	• Development of innovation • Go/no-go moments • Get project awarded	• Execution of the project • Implementation of the innovation
Design stage	*Sketch design*	*Temporary design*	*Definitive design*	*Execution design*

Figure 3.2: Innovation Partnership procedure

3.1.1. Summary

What is an Innovation Partnership? An Innovation Partnership is a procedure that includes the Research and Development of an innovation within the procurement process. The Innovation Partnership includes four stages: Formulation of the tender, Tender phase, research and development phase, and implementation phase.

3.2. Level of specifications

This section extents the answer to sub-question 3b; What is the difference with other procedures? In the previous chapter, chapter 2 several procurement procedure are explained. Figure 2.6 gave an overview of the procedures to indicated the different steps taken during the procurement process. This section compares the procedures ones more based on the specification level in the tender invitation. The level of specifications is relevant because it reflects on the innovativeness of the markets' solutions.

Figure 3.3 the procedures are arranged on a sliding scale of specification in the tender invitation (this figure is an indication of the difference in specifications, not a measurable scale). The figure identifies three levels of specification. Level one, "problem definition is formulated", includes tender invitations in which the contracting authority only knows the problem and has an idea of the direction of the solution. Level two, "functional requirements are formulated", indicates specifications of a functional nature. Finally, at level three, "technical requirements are formulated", the contracting authority is able to define a complete and detailed understanding of the problem solution.

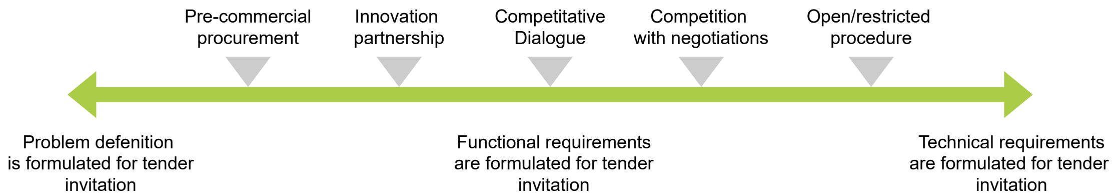

Figure 3.3: Level of specification of the tender invitation

In the case of a restricted/open procedure, a competition with negotiations, and a competitive dialogue, the contracting authority defines the direction of the solution to the problem themselves, after which they search a contractor to execute the solution. Depending on the possibility for negotiation or dialogues, the participants can discuss their options. However, it is never possible to negotiate on the selected terms of the minimum requirements. With either of these procedures, the contracting authority possesses the ability to provide a clear understanding of the nature of the solution (European Commission, 2018). There are considerable differences between these three procedures and Innovation Partnership. Then, for this research, the most relevant one is the level of specification of the tender invitation.

Like in the Innovation Partnership, in a SBIR procedure, the contracting authority has defined the problem but has only an idea of the problem's nature. The procedure includes the request of the contracting authority for an innovative solution to their proposed problem. An SBIR procedure relates to the research and development phase before the commercializing of the innovation. When the contracting authority decides to procure the innovation developed during the SBIR procedure, in most cases, the contracting authority must start a new procurement procedure to do so (European Commission, 2018). The procedure does facilitate the development of innovation which can be beneficial for future projects. "The contract can include the purchase of the innovation as long as the value of the services exceeds that of the products covered by the contract" (European Commission, 2018).

So, besides the difference in steps taken in the procurement process, there also is a difference in the level of specification included in the tender invitation. As explained in section 2.3.2 a minimal number of requirements stimulates the radicalness of the proposed solutions. Therefore, an Innovation Partnership can introduce more radical innovations than in procurement procedures where the specifications in the tender invitation are more technically defined.

3.3. Barriers for innovation

In the previous sections, the necessity for innovation as well as, the definition of innovation are elaborated upon. This section goes into detail on the barriers to innovation in the construction industry according to the literature. Table 3.1 provides an overview of the barriers thereby providing an answer to sub-question 3c. In section 9.2.2 these barriers will be evaluated with regard to the barriers found in practice. The barriers to innovation are mentioned in this research to provide an understanding on how the Innovation Partnership procedure facilitates innovation in the construction industry.

Table 3.1: Barriers for innovation

Barrier	**Explanation**	**Mentioned by**
Clients and manufacturing firms	Clients (contracting authorities) have the capability to influence firms and individuals in a way that fosters innovation.	(Blayse & Manley, 2004; Gambatese & Hallowell, 2011)
Buyer-supplier interaction	Interaction between supplier and buyer in an early stage enables the exchange of knowledge, which can be used to draw up better tender specifications.	(Uyarra et al., 2014)
Structure of production	The uniqueness of a construction project limits the applicability of the given innovation in other projects. It also results in different solutions for similar or identical client requirements, and organizational learning is hindered.	(Blayse & Manley, 2004; Gambatese & Hallowell, 2011)
Industry relationships	The importance of this relationship lay in facilitating knowledge flows through interactions and transactions between individuals.	(Blayse & Manley, 2004)
Procurement structures	Procurement systems can discourage innovation when the system includes rewards on speed and price alone.	(Blayse & Manley, 2004)
Procurement capabilities	A shortage of commercial skills among procurers has commonly been found to limit engagement with the marketplace and the development of closer supply relations. Lack of procurement expertise for complex purchases involving innovation was identified.	(Uyarra et al., 2014)
Tender specifications	Specifications phrased in terms of outcomes or performance are better at allowing innovations.	(Uyarra et al., 2014)
Regulations/standards	It is established that government regulations strongly influence the demand and have an essential role in the direction of the technical solution. Innovation can be encouraged through regulations and standards when they only specify the end goal.	(Blayse & Manley, 2004; Gambatese & Hallowell, 2011)
Organizational resources (Lack of technical capabilities)	For innovation to succeed, it is crucial for firms and individuals (contractors) to possess the right attitudes and processes to conduct innovation. Knowledge and technical resources available within the company.	(Blayse & Manley, 2004; Gambatese & Hallowell, 2011)
Public demand for innovation	Suppliers will be innovative if the procurer is a demanding client.	(Uyarra et al., 2014)
Long payback period	Development of an innovation is a great investment, payback period is long.	(Gambatese & Hallowell, 2011)

The incentive for the supplier of innovative solutions	Even if the demand of innovation is present, incentive (drijveren/prikkel) may not be in place.	(Uyarra et al., 2014)
Clients fear of change	With change, more uncertainty is introduced. "They know this way is working".	(Gambatese & Hallowell, 2011)
Lack of recognition on the value of innovation	Client does not see the surplus value of using an innovation.	(Gambatese & Hallowell, 2011)
Management of risks associated with procuring innovations	public agencies tends to avers risks. The importance of risk management increases when the R&D is part of the procurement. When procurers are risk-averse, suppliers might be reluctant to invest heavily in R&D and innovation activities if they fear they will not get the necessary return.	(Uyarra et al., 2014)
Management of intellectual property rights (IPR)	The way the IPR is managed influences the incentive structures of suppliers within public procurement procedures.	(Uyarra et al., 2014)
Access to tenders and other process-related constraints	Small and medium enterprises can not have access to the tender. Thus, their potential to deliver innovative solutions is not used. Also, the lack of spillover between the public and private sectors reduces innovation procurement's catalytic effect.	(Uyarra et al., 2014)

3.3.1. Innovation Partnership and barriers for innovation

Reflecting on table 3.1, barriers that Innovation Partnership deals with include (1) lack of recognition of the value of innovation, (2) missing incentive for suppliers of innovative solutions, (3) regulations and standards, and (4) structure of production. When a contracting authority procures a project through an Innovation Partnership, they show their initiation to include innovation in their project to achieve their project goals. Their innovation intention facilitates the recognition of the value of innovation. Furthermore, by procuring the project through an Innovation Partnership, the contracting authority creates an innovation incentive for the market.

The third barrier mentioned in the previous paragraph, standards and regulations, is tackled in the research and development phase of the Innovation Partnership. The contracting authority requests a proven solution, hence the regulations and standards. Because the R&D of the innovation is included in the procedure, the innovation complies with the standards and regulations at the start of the execution phase. Where needed, the testing of the innovation is included in the R&D phase as part of the TRL-ladder.

Another barrier an Innovation Partnership deals with is the structure of production. An Innovation Partnership can be embedded in a larger program of projects. The innovation is developed and executed for one project, after which the innovation can be duplicated to other similar projects which are part of the same program.

The literature also indicated the clients fear of change as a barrier. This barrier is cover by an Innovation Partnership not only for the client. Other stakeholders in the project will be in fear of change. This barrier is overcome by assessing and monitoring the readiness of different stakeholders. The fear for change is based on the uncertainty that comes with the change Lodder et al. (2017). The following section elaborates on how to manage stakeholders and assess their readiness for change.

3.3.2. Stakeholders engagement

Management of stakeholders is part of project management. In projects with innovations, the management of stakeholders is essential. Management of stakeholders begins with the identification of stakeholders affected by the project, after which their interests and influence are assessed, and an engagement plan is composed (Nicholas & Steyn, 2017; Schilling, 2018). Stakeholders include stockholders, employees, customers, operators, suppliers, lenders, communities, government organizations, and competitors (Ackermann & Eden, 2011). Stakeholders have to be taken into account because they can influence the project negatively when they are not managed correctly.

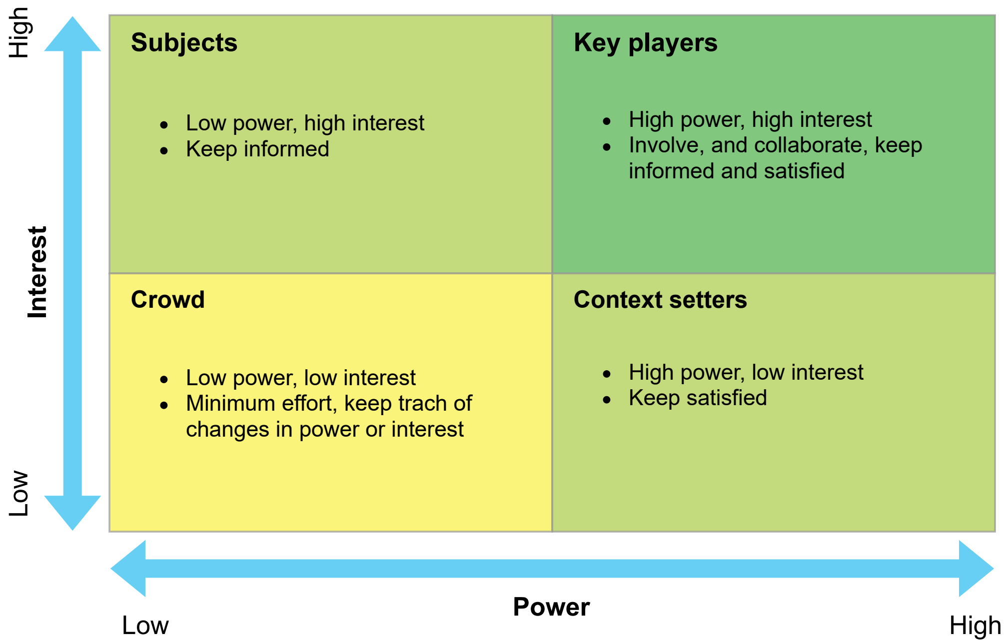

Figure 3.4: Power-interest diagram (Ackermann & Eden, 2011; Nicholas & Steyn, 2017)

The engagement of the stakeholders depends on the influences they have on the project and their interest (Ackermann & Eden, 2011; Nicholas & Steyn, 2017). Stakeholders can be divided into four quadrants; see figure 3.4. The most important stakeholders are the ones in quadrant "key players". Therefore they should be informed about what is happening in the project, and they have to be kept satisfied. When a key player is opposed to the project, they can stop the project or cause delays. Also, stakeholders in the quadrants "subjects" and "context setters" should be monitored in the project. Whenever subjects gain power in the project or context setters gain interest in the project, they become key players (Ackermann & Eden, 2011).

3.3.3. Stakeholder readiness

Rijkswaterstaat has developed a tool to measure the readiness of an organization and the environment (Rijkswaterstaat, 2021). This tool assesses, among other things, the stakeholders' fear of change, which has been identified as a barrier to innovate in the literature by (Gambatese & Hallowell, 2011). Rijkswaterstaat (2021) and Karstens (2018) identify that the readiness of stakeholders is driven by 5 components:

1. Value of the innovation
2. Support for the innovation inside the organization and the potential opposed parties
3. Costs for the development and the utilization of the innovation

4. Suitableness of the innovation in existing processes and need for change to make the innovation fit the process

5. Risks awareness and manageability of the risks

The sequence of the components is important. Rijkswaterstaat (2021) state that whenever the value of the innovation is not recognized, or there is no support for the innovation, it makes it difficult to pass the other components of the stakeholder readiness. However, it is essential to weigh out all components to make a suitable assessment (Rijkswaterstaat, 2021).

This tool aims to indicate how and when the organization and the environment should be taken into account (Karstens, 2018). Therefore, when the SRL is introduced and used in an early stage of the project, the innovation is more likely to be accepted, and the research and development costs will not go to waste (Karstens, 2018).

3.3.4. Adoption of innovation in general

For technological innovations five adopter categories can be identified (Schilling, 2018; Rogers, 2003):

1. Innovators: Adventurous individuals who are comfortable with a high level of uncertainty and can afford the losses related to unsuccessful adoption decisions.

2. Early adopters: Individuals who are respected members of their social system are looked at for information and advice.

3. Early majority: Adopt an innovation slightly before the average member of a social system

4. Late majority: Approach the innovation more skeptical and adopt the innovation following from peer pressure. They may have scarcer resources, making them more hesitant to invest in the innovation until most of the uncertainties are resolved.

5. Laggards: Base their adoption of the innovation on experiences rather than their social network. They need certainty that the innovation will not fail before they adopt it.

Figure 3.5 shows the bell curve for the categories of adopters over time.

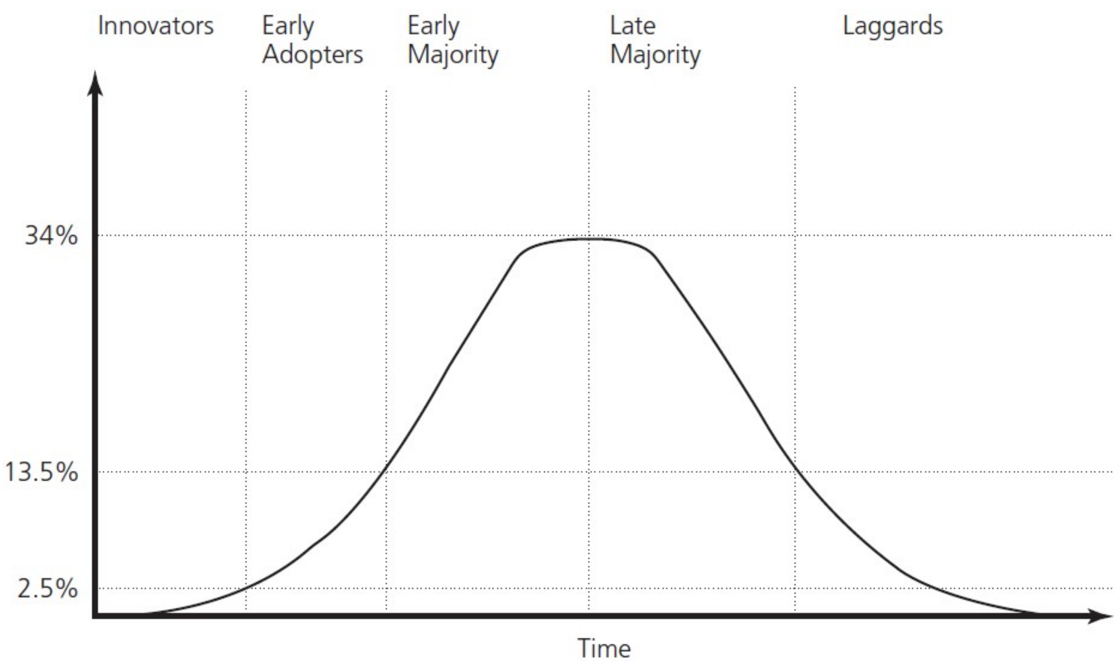

Figure 3.5: Categories of innovation adopters over time (Schilling, 2018)

Looking and the adoption of innovations in the construction industry, Winch (1998) states that either the innovation is adopted by a firm and implemented in a project (technology push), or the innovation is a result form the problem solution to a specific project (demand-pull). In an Innovation Partnership, the innovation is adopted by the contractor who implements the innovation in the project.

3.3.5. Summary

Barriers to innovation indicated in the literature are summarized in table 3.1. The Innovation Partnership overcomes barriers including: lack of recognition of the value of innovation, missing innovation incentive for the market, regulations and standards, and client's fear of change. That last barrier is not only applicable to the client but also to other stakeholders in the project. They have to be informed and engaged prior to and during the project to prevent resistance.

4. Risk management for projects with innovation

In chapter 2 the need for risk management and a risks management method is elaborated upon to establish a basic understanding of risk management. In this chapter, section 4.1 explains several types of risks. Unforeseen risks are explained, and types of risks specific to a project with innovation are discussed. To conclude, the chapter section 4.2 explains the allocation of risks in different contractual models. Finally, the chapter answers sub-question 4; How does the use of a product innovation in a project affect the way risks and uncertainties related to innovation are managed in a project? The answer to this question determines how the contractor and the contracting authority can design their contract to deal with risk aversion when including and innovation in the project. Figure 4.1 visualizes what will be discussed in this chapter.

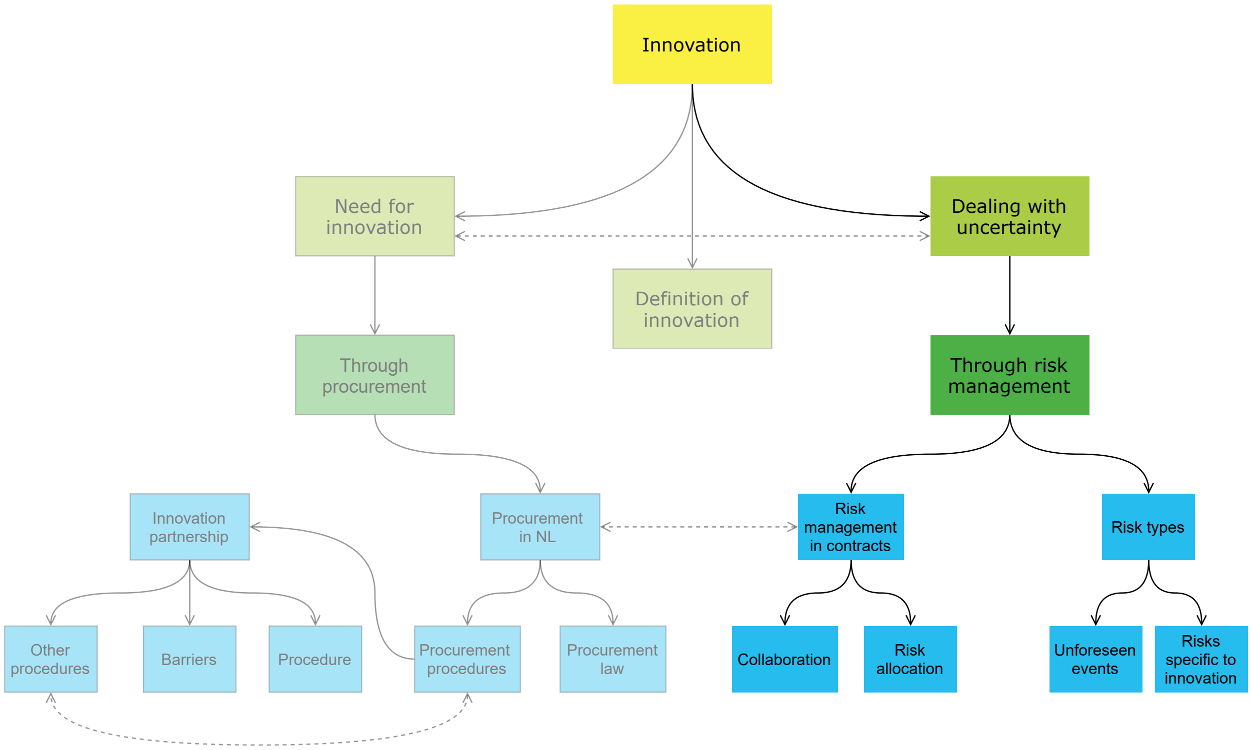

Figure 4.1: Literature: Risk management

4.1. Risk types

Stosic et al. (2017) Identify several types of risks, including: financial risks, design risks, operational and managerial risks, political risks, social risks, technical risks, legal risks, or environmental risks. These are types of risks that can occur in any project. For projects with innovation, not all risks can be identified upfront. Another type of risks, therefore, are unforeseen risks or events. The next section elaborates on those.

4.1.1. Unforeseen events

Besides risks that can be identified upfront, the chances are that positive and negative unforeseen events will appear in the project. In a project that includes innovation, it is more difficult to predict all risks compared with a project which has been done before (Procurement of innovation platform, 2014). Therefore, dealing with unforeseen uncertainties has a higher urgency in a project organization developing an innovation. Unforeseeable uncertainties can be defined as "unknown unknowns" (Loch et al., 2008).

"Unforeseeable uncertainty requires methods that go beyond risk management" (Loch et al., 2008, p. 32) a project can cause unknown unknowns. A project with innovation that is procured by an Innovation Partnership can be labelled as complex. These projects involve large scale purchases of innovation which have to cover large amounts of solutions. Risk management involves identifying the risks, assessing the risks, and planning the appropriate responses to the risks (Nicholas & Steyn, 2017). However, what if the risks are not identifiable? The unforeseen risks and gains can be labelled as "unknown unknowns" (Loch et al., 2006). During the project, risks are continually identified, assessed, and managed (Nicholas & Steyn, 2017). When a risk occurs and has not been identified, it should be managed in accordance with the allocation of responsibilities indicated in contractual agreements.

4.2. Risk management in contracts

Before recommendations can be made on how risks should be allocated or shared when innovation is included in a project, it is necessary to know how existing contractual agreements deal with risks.

In their article Nyström et al. (2016), try to identify the difference in design freedom of the contractor in a Design-Bid-Built (DBB) contract versus a Design & Built (DB) contract. They conclude that theoretically, a DB contract has more design freedom, whereas, in a DBB contract, the client carries all the risks. However, in practice, it appears that the difference between a DBB and a DB contract in design freedom is non-existing.

Design freedom and innovation are positively correlated; the contractor can create and use new technologies with more design freedom. When the contracting authority sets the design without space for the contractor, the contractor has no opportunities to innovate. Nyström et al. (2016) proposes some solutions to stimulate innovation in the construction industry. One of these recommendations is early contractor involvement and development of innovation in close collaboration. Winch (1998) also states that the incentive to innovate is essential. All parties involved in innovation development have to have the same goal. If the incentive to innovate is not present in the project organization, the innovation is not likely to be successful (Winch, 1998).

Approaches that include design and construction activities can lead to an improvement in design constructability and economy through innovation (Blayse & Manley, 2004). Relationship management can enhance the performance of an integrated construction team, especially when a partnership or alliance is chosen Blayse & Manley (2004).To be able to innovate in the construction industry, Winch (1998) states that; in an integrated project delivery method where design and construction activities are combined, there is more space for innovations if there is the incentive to innovate.

As Winch (1998) describes, shifting from competitive tendering towards partnering provides the opportunity to develop a gain/risks sharing approach. "Those in a position to innovate need to be rewarded for taking such risks" (Winch, 1998, p. 274). Gain- and risk-sharing establishes an equal motivation for all parties to deliver the project according to the set requirements.

The conclusion can be drawn that close collaboration and gain and loss sharing are most important when procuring an innovation. Here, "close collaboration" creates the right incentive in the whole project organization, and the gain and loss sharing establishes a common goal. Therefore, the following section elaborates on four types of contractual models to determine which model is, or which parts of the models are, most suitable for an innovation project.

4.3. Building contract models

Four contract models are discussed in this section with a focus on the allocation of responsibilities and liabilities. The four types of contract models discussed are: the traditional contract, the integrated contract, a "bouwteam" agreement (in literature translated as: early contractor involvement, design team or building team), and alliances. The scope of this research includes the Dutch construction industry, and therefore contracts mainly used in other countries (e.g. NEC or Fidic) are not included in this research.

The four different models mainly differ in the amount of influence the contracting authority has on the project and the corresponding liabilities (Chao-Duivis et al., 2018). The four contractual models are discussed, focusing on the allocation of responsibilities, ownership of the intellectual property rights and copyrights, and what the contracts state about dealing with unforeseen circumstances. Other aspects of the contract models are not discussed.

4.3.1. Traditional contractual agreement

A traditional contractual agreement is a hierarchical agreement between the contracting authority, the consultant or architect, the contractor and the subcontractors. Figure 4.2 shows the design of a traditional contractual model.

In the traditional model, the contractual agreement between contracting authority and contractor is governed by the general condition of the UAV 2012 (Dutch: Uniforme administratieve voorwaarden; English Uniform administrative conditions (UAC 2012)) (Chao-Duivis et al., 2018). Following these general conditions, the contracting authority is responsible for the design, and the contractor is responsible for the execution of the design. The contracting authority also has an agreement with an architect and, if needed, (other) engineering consultant(s). That agreement is based upon the DNR 2011 (Dutch: De Nieuwe regeling 2011; English: The New Rules 2011 (TNR 2011)). There is no contract in place between the consultants and the contractor. However, there exists a functional relationship between these two parties (Chao-Duivis et al., 2018). The design phase and execution are separate phases that are consecutive. The UAV 2012 and the DNR 2011 are further elaborated upon in sections 4.3.1 and 4.3.1 respectively.

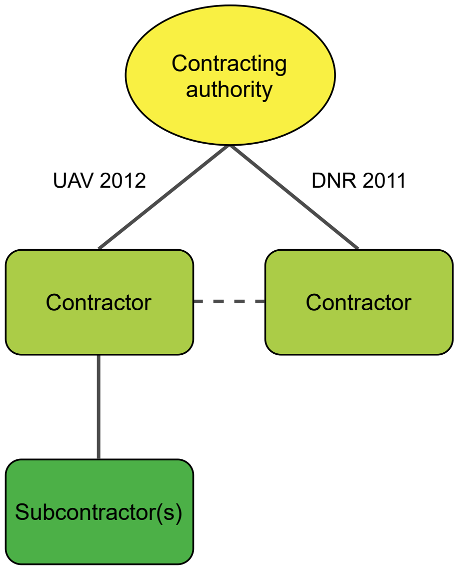

Figure 4.2: Traditional contractual model (based on Chao-Duivis et al. (2018))

UAV 2012

Minister van economiesche zaken landbouw en innovatie & Minister van binnenlandsezaken en koningrijksrelaties (2012) The UAV 2012 (Minister van economiesche zaken landbouw en innovatie & Minister van binnenlandsezaken en koningrijksrelaties, 2012) are the general terms and conditions of the contractual relationship between contractor and contracting authority (Chao-Duivis et al., 2018). The general term and conditions describe the obligations, responsibilities and liabilities of the contracting authority, the contractor.

Responsibilities of the contracting authority

The principle of the responsibilities of the contracting authority is set out in the UAV 2012 §5. The primary responsibilities for the contracting authority are: payment of the contract sum, delivering the design, enabling the works to be carried out, and supervision through an agent (Chao-Duivis et al., 2018). In addition, the responsibility for the design includes the responsibility for the construction methods and materials and all instructions given by the contracting authority or the agent (Chao-Duivis et al., 2018).

Responsibilities of the Contractor

On the other hand, the contractor's primary responsibility is to carry out the works (Chao-Duivis et al., 2018). The principle of the responsibilities of the contractor is set out in §6 of the UAV 2005. The contractor is obligated to carry out the work laid down in the general terms in the UAV 2012. The specifications on how to execute the works are agreed on in the contract Chao-Duivis et al. (2018). Following the UAV 2012, the contractor is (among other things) obligated to (Chao-Duivis et al., 2018; Festen-Hoff et al., 2011): follow orders and directions from the contracting authority, provide labour, construction materials and plants, carry out the works within the agreed time limit, warn the contracting authority of any errors or defects, carry out the works himself, be present during the work, and rectify any defects and repair any damages within the liability period.

Consulting contractual agreement DNR 2011

The contractual agreement between the contracting authority and the consultant is governed by the DNR 2011 BNA & NLingenieurs (2011) (De nieuwe regeling 2011). A consultant can be, among other things, an architect or a consulting engineer (Chao-Duivis et al., 2018). Depending on the expertise of the consultant, they are needed in different phases of the project. For instance: an architect is part of the design phase, whereas a consultant on specific execution methods is needed to execute the project.

Responsibilities contracting authority

With a DNR the responsibilities of the contracting authority include their duty to cooperate, their duty to warn, and payment of the contract sum (Chao-Duivis et al., 2018).

Responsibilities Consultant

In table 4.1 the responsibilities of the contracting authority and the consultant, according to the DNR 2011, are set out.

Table 4.1: Responsibilities in the DNR 2011

	Responsibilities	**Liabilities**

Contracting authority (in the role of client)	• Provide necessary cooperation for the consultant to carry out commissioning, e.g.:
	  ○ Review
	  ○ Sign of approval
	  ○ Deliver needed information
	• Deliver correct data
	  ○ Including data provided by other consultants
	• Duty to warn of any shortcomings in the consultants' advice
	• Pay contract sum
		• Liable for the works that have been accepted

Engineering consultant/ architect (incl. agent)	• Only take on commissions that they are capable of handling • Act in the same way as reasonably acting professional colleagues, with the required expertise • Deliver a legally practicable design; a design in accordance with the rules and regulations • Duty to warn and inform • Deliver works within agreed upon time limits • Take out liability insurance	• Liable when there is an imputable failure on the part of the consultant, and the consultant is in default

Responsibilities traditional model

In table 4.2 the responsibilities of the contractor, contracting authority, consultant, and the sub contractors are set out per project phase.

Table 4.2: Responsibilities in a traditional contractual model

	Problem definition	**Development/design**	**Execution**	**Maintenance (period after completion)**
Contracting authority (in the role of client) UAV par. 5	• Technically specify the work that has to be execution	• Deliver the design • Provide working methods • Assign agent • Enable execution	• Supervision of the work through an assigned agent • Pay contract sum	• Inspect the works • Accepting the works
	Liable for: • The content of the specifications	*Liable for:* • The provided design, • Prescribed working methods, • The agent • Activities to enable execution of the works	*Liable for:* • Supervision of the execution • Payment of the agreed-upon contract sum	*Liable for:* • The work after completion. For the exception, see contractors liabilities after completion.
Consultant/ architect (incl. agent)	*DNR 2011*	*DNR 2011*	*DNR 2011*	*DNR 2011*

Contractor
UAV par. 6, 8, 9, 11
		• Pre-contractual duty to warn	• Execution of the works
			• Duty to warn
			• On-time completion of the works
				• No responsibilities after acceptance of the work by the contracting authority unless:
				  ○ The defect is attributable to the contractor and;
				  ○ Careful inspection during execution or inspection of the works could not reasonably have been discovered by the contracting authority and;
				  ○ The contractor has been informed within a reasonable time period after discovery.

		Liable for: • Failure to warn	*Liable for:* • Incorrect execution of the works • Failure to warn • Delays and budget overruns	*Liable for:* • Attributable defects that cannot have been discovered after careful inspection of the works by the contracting authority and that the contractor is informed of within a reasonable period after discovery
Subcontractor(s) UAV par 6.26 and 6.27			• Can only carry out part of the works with written approval from the agent • Subcontractors' work is the responsibility of the contractor except for a nominated and accepted subcontractor. Then the work is the responsibility of the contracting authority	
			Liability • Preform in accordance with the agreement	

Unforeseen cost-increasing circumstances

In the UAV 2012 §47, the mitigating rules for unforeseen cost-increasing circumstances are stated (Chao-Duivis et al., 2018). In essence, the contractor bears the risk for higher execution costs. Unforeseen circumstances (in this research defined as unforeseen events, and thus from this point forward called unforeseen events) form an exception to this rule. The exception occurs when:

- the occurring event did not have to be accounted for when entering into the contract,
- the contractor is not liable for the cost-increase and,
- the costs increase substantially as a result of the unforeseen event.

When a cost-increasing unforeseen event occurs as described above, the contractor is entitled to an additional payment.

Intellectual property

In a traditional model, an UAV 2012 is in place between the contractor and the contracting authority. See figure 4.2. In the UAV 2012, intellectual property is not addressed. The missing IPR in the UVA 2012 makes sense since the contractor only executes what the contracting authority instructs them to do. Therefore, under the UAV 2012 the intellectual property lies with the contracting authority.

On the other side of the triangle, between the contracting authority and the consultant, is a DNR 2011 in place. The DNR 2011 does discuss the intellectual property. It states that the consultant acquires intellectual property rights to the work they produce (Chao-Duivis et al., 2018). Therefore, the drawings and designs generated by the consultant enjoy copyright as long as they include a certain degree of originality. After handing over the documents, the contracting authority becomes the owner of the documents after completing the financial obligations. Copyrights, however, stay with the consultant.

4.3.2. Integrated contractual agreements

UAV-GC 2005

UAV-GC 2005 (2005) is created to facilitate integrated project delivery. UAV-GC stand for "Uniforme Algemene Voorwaarden Geïntegreerde Contracten" (Eng: Uniform Administrative Conditions Integrated Contracts. "Integrated contracts refer to the fact that design and execution are in the hands of a single party in relation to the client" (Chao-Duivis et al., 2018). This means that the contracting authority's influence on the design and execution is minimized as much as possible (Festen-Hoff et al., 2011). In this case, the "contractor" can be the building contractor (the one who executes the project) or the architect/consultant. Figure 4.3 shows the structure of an integrated agreement.

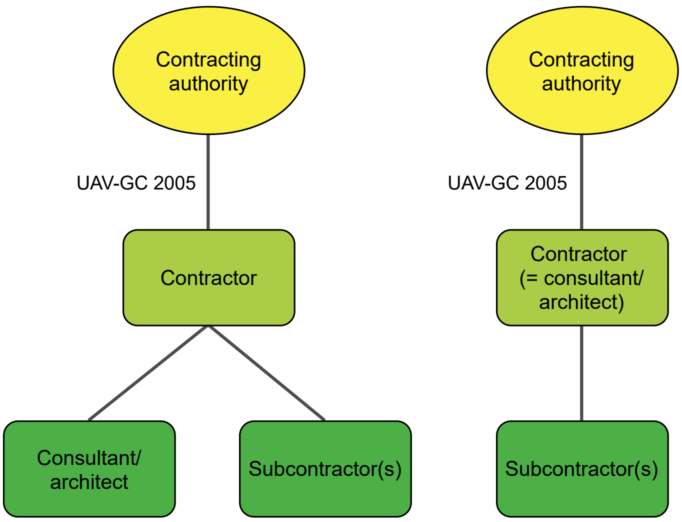

Figure 4.3: Integrated contractual agreement (based on Chao-Duivis et al. (2018))

The UAV-GC 2005 are a set of general terms and conditions that specify the legal relationship between the contracting authority and the contractor. In addition, the UAV-GC 2005 mention the responsibilities for contracting authority and contractor.

Responsibilities of the contracting authority

§3 of the UAV-CG 2005, sets out the responsibilities for the contracting authority. Because of the difference in organizational structure, the contracting authority's role in the project is different. Particularly the contracting authority's involvement in executing the projects differs from their responsibilities in the UAV 2012. Regarding the contracting authority's responsibilities, it is about placing at the contractors' disposal (Festen-Hoff et al., 2011). Their responsibilities include the obligation to provide the necessary information. The contracting authority has to ensure that contractor has proper access to the, in the client's requirements specified, land and water where the works are to be carried out, and the contracting authority must provide everything which is agreed upon in the Basic contract (Chao-Duivis et al., 2018; Festen-Hoff et al., 2011).

The contracting authority must pay the contractor. The UAV-GC specifies that the amount of money the contractor is entitled to is the amount defined in the Basic contract "plus or minus any other amounts due to/from the contractor in respects of the contract" (Chao-Duivis et al., 2018).

Responsibilities of the contractor

The primary responsibilities for the contractor are defined in §4 of the UAV-GC 2005. The principal obligation of the contractor is to execute the works following the requirements laid down in the contract within the set time frame (Chao-Duivis et al., 2018; Festen-Hoff et al., 2011). The second obligation of the contractor is his duty to warn of errors and effects in anything the contracting authority delivers.

When the works do not comply with the client's requirements, this constitutes a defect (Chao-Duivis et al., 2018). This clause obliges the contractor to deliver the works' fit for purpose'(Festen-Hoff et al., 2011). When, however, the contractor does not have the complete freedom to execute the work due to the active involvement of the contracting authority, the contractor can be discharged from this obligation (Chao-Duivis et al., 2018). Discharge happens when arbiters decide that the contractor can not be held responsible for the result of the work because the contracting authority did not obey the integrated nature of the agreement, and therefore acted as a contracting authority in a traditional contract (Festen-Hoff et al., 2011).

Wherewith the UAV 2012, the contracting authority has the majority of the responsibilities, with the UAV-GC 2005, the contractor holds the majority of the responsibilities. In addition, in an integrated contract, the contractor undertakes various types of works which all include responsibilities for which the contractor can be held liable (Festen-Hoff et al., 2011).

Responsibilities integrated model

In table 4.3 the responsibilities of the contractor, contracting authority, consultant, and the subcontractors are set out per project phase.

Table 4.3: Responsibilities in an integrated model

	Problem definition	**Development/design**	**Execution**	**Maintenance (period after execution)**
Contracting authority (in the role of client)	• Tender invitation • Specify technical and functional requirements (client's requirements)	• Deliver information relevant to the contractor that he has to his disposal • Preparation of land and/or water • Provide all the goods specified in the agreement		• Inspection of the work • Acceptance of the work
	Liable for: • The content of their requirements, even after change or completion following the contract formation	*Liable for:* • Damage due to any late or the incorrect provided information or other defects or errors relating to the provided information, land or water and goods • Changes to the contract or requirements are given by the contracting authority		*Liable for:* • The work after completion. For the exception, see contractors' liabilities after completion.
Contractor		• Execution of design in accordance with the requirements of the contracting authority • Make a design fit for purpose and in accordance with 'normal' and 'explicitly' stated requirements. • Duty to warn • Informing the contracting authority on quality insurance		
		Liable for: • "Defects": deviation of the contracting authority's requirements		*Liable for:* • The contractor is no longer liable for defects in the works unless: ○ *Maintenance is part of the contract* ○ The defects are the fault of the contractor, or it is his responsibility, and ○ The contracting authority did not notice these defects prior to completion and acceptance, and ○ The contracting authority could not reasonably have detected the defect at the time of acceptance of the work.
Engineering consultant/ architect (incl. agent)	*DNR 2011*	*DNR2011*		*DNR2011*
Subcontractor(s)	*See traditional model*	*See traditional model*	*See traditional model*	*See traditional model*

Unforeseen circumstances

In the UAV-GC §44 an exhaustive list of circumstances is given in which the contractor is entitle to reimbursement of costs and/or an extension. One of these circumstances is the occurrence of "unforeseen circumstances" (in this research: unforeseen events) (Chao-Duivis et al., 2018). The unforeseen events are events that are not included in the contract either explicitly or implicitly. The contractor is entitled to reimbursement of costs and/or extension whenever unforeseen events occur that are of such a nature that the contracting authority can not, following standards of reasonableness and fairness (Maatstaven van redelijkheid en billijkheid), expect the contract to remain in force unchanged (Chao-Duivis et al., 2018).

Intellectual property

The rules related to intellectual property are mostly based on the intellectual property rules in the DNR 2011 (Chao-Duivis et al., 2018). In essence, the rules state that the copyright of the design documents lies with the contractor. However, the contracting authority becomes the owner of the specific documents (the piece of paper) (Chao-Duivis et al., 2018).

4.3.3. Design team (Bouwteam)

In a design team, the contractor is involved from the early stages of the project. The contractor is involved for their expertise during the design phase of the project (Chao-Duivis et al., 2018). A design team is a collaboration between contracting authority, designers, and contractors with a common goal to accomplish a design (Boot et al., 2012). In the Netherlands there are three model bouwteam agreements: VGB 1992 (VGBouw, 1992), DG 2020 (Duurzaam gebouwd, 2020), and the BNL 2021 (Bouwend Nederland, 2021). Besides the contractor, the design team can include other experts and consultants, see figure 4.4.

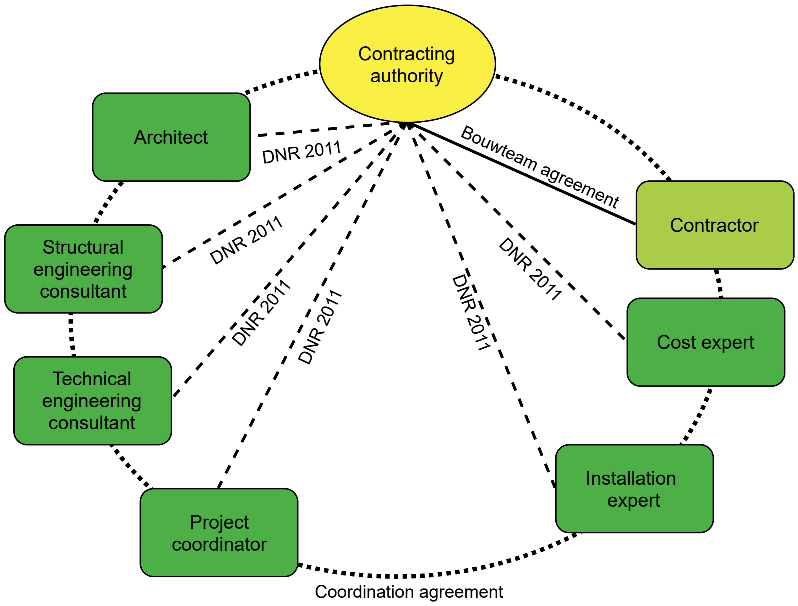

Figure 4.4: Bouwteam (based on Chao-Duivis et al. (2018))

Even tho the contractor is involved in the design, they are not necessarily chosen for the execution of the project (Chao-Duivis et al., 2018). In table 4.4 the responsibilities of the contracting authority, contractor and the rest of the design team are set out based on the model agreement VGB 1992. Only between the contractor and the contracting authority, a design team agreement is in place. Between the other members of the design team and the contracting authority, a DNR 2011 is in place and between all members of the design team is a coordination agreement in place.

Table 4.4: Responsibilities in a design team

	Problem definition	Development/design
Contracting authority (in the role of client)	• Specify desires and demands regarding the project	• Leading the Bouwteam • Checking and coordination of the work of the individual parties • Taking and communicating all decisions needed for the progress of the project preparations • Communication with authorities (bevoegd gezag) to obtain the required licenses and permissions. • Deliver all information relevant he has to his disposal • Deliver a legally practicable design; a design in accordance with the rules and regulations
The Design team		• Duty to warn • Prepare a project in such a way that this will result in a design acceptable for the contracting authority • Plan and design of own work in accordance with the general planning and instructions from the contracting authority • Further bound to the individual contract
		Liable for: • Every party is liable for their own part of the design • When advice coming from another member of the design team is accepted and adopted, the liability shifts to the adopting member of the team. • There is no collective liability • Based on the DNR 2011

Contractor		• Offer specific experiences and expertise of construction and the associated costs available to the design team. As long as this is reasonably desirable as part of the preparations of the project to arrive at a design that is acceptable to the contracting authority. Including:
		    o Advising on optimisation of costs
		    o Advising on the technical and financial feasibility of the whole project and of the design
		    o Draw up alternatives
		    o Make a planning for preparation and execution
		    o Other project-specific things

		Liable for: • See DNR 2011

Intellectual property rights

The intellectual property rights (IPR) are not discussed in the model agreement VGB 1992. In the DG 2020, the IPR lay with the contracting authority (Duurzaam gebouwd, 2020, art. 14). The IPR include but is not limited to copyright (Duurzaam gebouwd, 2020). The contracting authority also becomes the owner of all documents, drawings, and calculations unless the parties explicitly and in writing agreed otherwise. In the case that the agreement is terminated before completion, the contracting authority may not use documents drawn up by the contractor until they have fulfilled their financial obligations (Duurzaam gebouwd, 2020).

4.3.4. Alliance

In an alliance, the contracting authority and the contractor enter into a partnership so that they treat each other equally (Chao-Duivis et al., 2018). In an alliance, there is no hierarchy between parties, loss and profit is shared, and there is no risk allocation because risks are dealt with together (Chao-

Duivis et al., 2018). Jefferies et al. (2014) states that alliancing utilizes the principles of risk-sharing to develop relationships better and integrate the teams to maximize project performance. "The project team jointly takes on the full responsibility to complete the project. The team jointly shares in the management of any achievements (profits) and failures (losses) that arise in a "we all win, or we all lose" mentality" (Harper et al., 2016).

An alliance can cover one project (project alliance) or multiple projects over a more extended period (strategic alliance) (Boot et al., 2012). For this research, the next part is based on a project alliance. The scope of this research includes projects procured by an Innovation Partnership and will therefore include project organizations composed for that specific project.

A project alliance can be specific for a particular phase of the project. For example, an alliance for the design phase for a project can be composed. Then, the execution of the project will be done through another contractual agreement (Boot et al., 2012). This alliance form is suitable for big projects, more complex projects of projects where risks are hard to identify upfront (Boot et al., 2012).

Risk sharing in the alliance

The alliance fund, explained further in this section, facilitates joint risks bearing for the risks assigned to the alliance. Whether the risks are allocated to the alliance or one of the alliance parties depends on: the level of influences a party or both parties have on the risks, and whether or not a party can bear the risk (Boot et al., 2012). With these factors Boot et al. (2012) identifies four categories in which the risks are allocated or shared:

1. Risks can be influenced and borne by both parties; decisions for the design
2. Risks can be influenced and borne by only one party; obtaining permits, contractor's errors, consultants errors, location
3. Risks can not be influenced by and can not be borne by either party; environmental disasters, weather, inflation
4. Risks can not be influenced by and can not be borne by either party but the risk only impacts one party; changes in regulations, strikes

Risks that can be managed by one specific party in the alliance can be kept outside of the alliance. However, the essence of an alliance is that the risks are managed jointly (Boot et al., 2012).

Sharing of risks (possible profit or losses) is not evident. 'Profit' is not the same for the contractor and the contracting authority (Boot et al., 2012). For the contracting authority, profit or surplus value is the difference between the created value of the project and the price they paid for the project. In contrast, surplus value for the contractor consists of the difference between project delivery costs and the price they get paid for the completed project. To establish an equal collaboration and reach joint goals, the surplus value of the alliance partners has to be equalized (Boot et al., 2012).

Overcoming this difference can be done by the use of a shared risk fund. On the one hand, this fund can be used to pay costs and possible losses jointly, and on the other hand, the remaining credit can be shared equally at the end of the project (Boot et al., 2012).

Unforeseen circumstances

An alliance is a partnership in which losses and profits are shared (Jefferies et al., 2014; Harper et al., 2016; Barlow, 2000). These risks and gains include risks caused by unforeseen circumstances.

Intellectual property rights

In the Netherlands, there are no standard conditions for an alliance agreement. Therefore, ownership of the intellectual property rights might vary per project and depend on the agreements made in the contractual negotiations (Teng, 2007).

4.4. Summary

Sub-question 4; How does the use of a product innovation in a project affect the way risks and uncertainties related to innovation are managed in a project? Can be answered at this point. The main difference between a project that includes an innovation, and a project not including an innovation, is the level of uncertainty. Because innovations bring higher levels of uncertainties that can not all be identified upfront but might have a significant financial impact on the project, the relationship between the contractor and the contracting authority should be more collaborative. When a project is governed by either the UAV 2012 or the UAV-GC 2005, responsibilities and liabilities are specified detailedly. However, sharing losses and profits is better suitable for a project including innovation, where unforeseen events are probable.

II
Practical experiences

Introduction

The second part of the research explores recent experiences with procurement of projects in the construction industry that include innovation. The experiences are gathered through interviews. In appendix A the questions and propositions are presented. The interviews are divided into four parts. The first part was a general introduction to the research objective and an introduction of the respondent and the interviewer. In the second part of the interview, the respondent was asked about barriers to innovations in the GWW and unforeseen events they have experienced. The third part of the interview discussed the procurement of innovations and the procedure Innovation Partnership. The fourth and final part was the round-off. Here the respondent could make final comments.

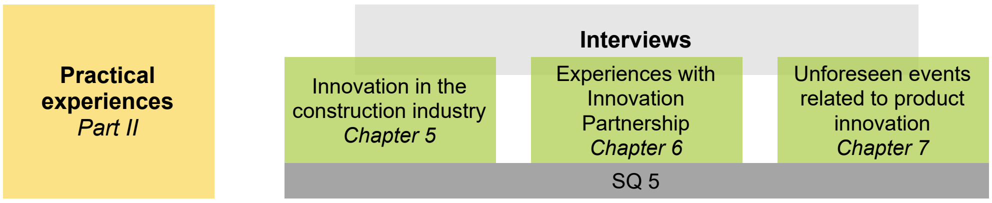

Figure 4.5: Part 2 - Practical experiences (Full scheme see figure 1.2)

Figure 4.5 shows part of the, in chapter 1.5 explained, methodology. The figure indicates which parts of the interviews are used to establish practical insight into the procurement of projects including innovation.

This part of the report details the current barriers to innovation experienced in practice, specific experiences with unforeseen innovation-related events, and experiences with Innovation Partnership. The structure of this part is similar to the previous part. In chapter 5 the need for innovation and the need for procurement of innovation are discussed, chapter 6 elaborates on the experiences with Innovation Partnership, and chapter 7 highlights risk management for projects with innovation. The chapters answer sub-question 5; How, in current practice, are innovations included in construction projects?

5. Innovation in practice

In this chapter, the practical experiences related to the need of innovation (section 5.1) and the need for procurement of innovation (section 5.2) are summarized. In contrast to chapter 2, this chapter gives an practical insight to these topics.

5.1. Need for innovation in practice

Confirmation of the necessity of innovation is found in practice. Respondents mention PFAS regulations, circularity, zero-emission construction, nitrogen restrictions, and the renovation of existing infrastructure as major events in the current construction industry. These are issues that have an impact on a national level. In the interviews, respondents also broach project-specific problems which require innovation. Project-specific demand for innovation is mainly about a specific time limit that has to be met, or project goals can not be reached with the existing expertise and knowledge available.

One of the respondents mentioned, "necessity is the mother of innovation" (Interview 7). With this, the respondent argued that when the urgency for innovation is present, the development of the required innovation will follow quickly.

5.2. Including innovation in procurement

Stimulating innovation by including innovation in a tender invitation is, according to the respondents, possible. Including innovation in a tender invitation, the innovativeness of the market is triggered (interviews 5 and 6). According to the respondents, if and how innovation should be included in the tender invitation is elaborated further on in this section.

5.2.1. Innovation as part of the tender invitation

In the interviews, the respondents were asked if, according to them, it is better if an innovation is included in the tender invitation by the contracting authority or if it is better when a contractor develops an innovation and includes it in the project independently. The overall reaction to this hypothesis was that it would be difficult for a contractor to create and include an innovation in the project when the contracting authority did not request an innovation. "It is more difficult for a contractor to introduce something the contracting authority does not ask for than it is for a contracting authority to ask for something the market does not yet have" (Interview 7). This reaction came from a contracting authority indicating that it is easier for a contractor to develop something at the request of a contracting authority than for a contractor to convince a contracting authority of their innovative idea.

Other interviewees agreed with that. "An innovation will probably be more successful when it is included in the tender because then, the needed resources for the successful implementation are present" (interview 3). Interviewee 5 stated that the most crucial aspect for successful implementation of an innovation is that the contracting authority at least realizes that the urgency for innovation is present. However, on the other hand, the contracting authority and the contractor must recognize that the innovation in itself is not the projects' end goal. It is part of the project. "A contracting authority should be aware of making the innovation the end goal. They should present the project and mention that they do not have a solution and they think an innovation is required." (interview 5).

Respondents 5 and 9 mentioned that to introduce innovation in a project successfully, the contracting authority should pinpoint the urgency for innovation. "A contracting authority can leave the problem or challenge they face with the market and ask the market what they think could be the solution"(interview 9). Additionally, "when the formulation of the tender invitation includes an ’impossible’ challenge, it utilizes the innovativeness of the market" (interviews 5 and 6). These statements emphasize the importance of the formulation of the tender invitation by the contracting authority.

5.2.2. The incentive of the tender invitation

In interview 8, the respondent mentioned: "when a contractor introduces an innovation, it is possible that the contracting authority does not agree with the development stage it is in and therefore leaves all risks at contractors side, or does not want the innovation included in the project at all.".

Even though the respondents agreed on the preference of including the request for innovation in the tender invitation in every interview, an important side note is that the tender invitation must have a lot of "space" (interview 7). There must be enough space in the tender invitation for candidates to propose an innovative solution that can further develop during the tender (interview 7). In interview 9, the respondent also mentioned that the incentive of the tender should be more important than the content. "To establish space to be innovative, the tendency of the agreement is more important than the content" (interview 9).

5.3. Summary

Following the practical insights, the need for innovation is present. Challenges mentioned by the respondents are PFAS regulations, circularity goals, nitrogen restrictions, zero-emission execution of projects and the renovation of existing infrastructure. The output from the interviews indicated that the tender invitation should include innovation. At least, the contracting authority should utilize the innovative power of the market by disseminating the urgency for innovation and including enough ’space’ in the tender invitation. The space indicated in the interviews relates to the level of specifications. When the tender specifications are technically detailed, there is no opportunity for the contractors to come up with new ideas. In contrast, the more the specifications are functionally defined, the contracting authority leaves space for the contractors to develop their own solutions.

6. Experiences with Innovation Partnership

This chapter answers sub-question 5a; What are experienced barriers to innovation? And 5c; How is Innovation Partnership experienced in practice? First, the advantages and disadvantages mentioned by the respondents are summarized. In section 6.2 the experienced barriers to innovation are discussed.

6.1. Innovation Partnership in practice

In the interviews, the respondents were asked some questions about the Innovation Partnership procedure. As mentioned in the introduction of this part, most respondents are currently working on a project procured by an Innovation Partnership. Additionally, one respondent completed a project procured with an Innovation Partnership. One was familiar with the procedure but did not have experience with it, and one was not familiar with the procedure.

6.1.1. Benefits

In the interviews, it became clear that Innovation Partnership has upsides but also some pitfalls. According to the respondents, an Innovation Partnership offers the contracting authority a guideline to procure innovation (interviews 3, 5, 6). With this guideline, contracting authorities are more eager to take on the risk to procure innovation because they know they have the procedure to fall back on. Besides that, the innovation incentive of a contracting authority is evident when they use an Innovation Partnership to procure their project. "The fact that a contracting authority chooses an Innovation Partnership gives a clear message that they not only 'say' they want to innovate, but they act on it as well" (interview 5). "What the use of an Innovation Partnership carries out is that everyone knows that you want to innovate fundamentally" (interview 7). Therefore, whenever a contracting authority is not eager to innovate, they will not use an Innovation Partnership.

Collaboration between the contractor and contracting authority is critical in an Innovation Partnership. The close collaboration and the joint decision moments (go/no-go moments) facilitate negotiations on risk allocation, and the collective project goal creates a giving environment (interviews 2, 4). The decision moments, otherwise known as go/no-go moments, have another advantage; the checkpoints facilitate joint decision-making in what direction the solution goes and how it meets the requirements set by the contracting authority. In addition, the go/no-go moments help deal with the uncertainties of innovating. On the one hand, the contractor can check if they are still on the same page as the contracting authority, and the contracting authority can check if the innovation still meets the requirements (interview 8).

Interviews 4, 5, and 7 also highlight stakeholder involvement as an advantage of an Innovation Partnership. Section 6.2 goes further into detail on why stakeholder involvement is essential for projects with innovation.

6.1.2. Disadvantages

Besides the many benefits mentioned in the interviews, the respondents are also critical. As discussed in section 2.3.3, Innovation Partnership is a significantly different procedure. The respondents mention the long-running time as a considerable disadvantage of the procedure (interviews 2, 4, 6, 7, and 8). In interviews 3, 4, and 6, the risks of the procedure are pinpointed. "Innovation Partnership is a different procedure where solutions are asked with a different risk profile, with a different duration, and possibly with several contractors. That results in a different kind of dynamic" (interview 6).

The design of the procedure is the responsibility of the contracting authority. The description of the procedure in the procurement law is only a guideline. To utilize an Innovation Partnership to the fullest extent, contracting authority must include all the 'space' an Innovation Partnership offers (interview 5).

The obvious disadvantage is the running time of the procedure. The innovation development is intertwined in the procedure, and depending on the TRL starting level of the innovation, the innovation development alone could take several years. Besides the duration of the innovation development, for the contractor, the procedure could be costly because development costs are mainly the responsibility of the contractors (interview 4).

6.2. Barriers experienced in practice

This section answers sub-question 5a; What are experienced barriers to innovation? A comparison between the obstacles mentioned in the literature and the interviews is made in section 9.2.2 in the next part.

Every respondent was asked what, according to them, are current barriers for innovation. Interviews 2 and 3 answered that the guarantee that the innovation will be purchased and that the grantee will be profitable or, at least, breaks even. The fear of not being profitable dominates the current industry. A more joint risk allocation could help with that (interview 1). Respondents 5 and 8 mention 'short-cycle thinking'. A contractor is focused on one project which has to generate profit. "The duration of a project generally is, from submission of the tender till the completion of the project two to five years. That duration is not long enough to go through a whole innovation trajectory"(interview 5). For respondent 9, the resources of an organization internally can form a barrier. Also, lack of capacity hinders innovation. An external obstacle that interview 9 mentioned was the regulations for innovation. Contracting authorities prefer 'proved' solutions, which contradicts with innovation. Also, respondents 6 and 7 indicate regulations as a barrier. The flexibility in the contracts is for respondent 4 the most significant obstacle. "We spent the last few years specifying every detail of the contract, and with that, the innovative power of the market is not utilized." (interview 4).

6.2.1. Stakeholder readiness

Stakeholder readiness is indicated as a barrier to innovation (interviews 4, 5, and 7). "You have to speak to every stakeholder that is influenced by the innovation. However, in most procurement procedures, that is not possible" (interview 5). "Contractor and contracting authority have a contract that facilitates communication between the two. Besides the contractor, the contracting authority also has to deal with all stakeholders. From the beginning of the project, the stakeholders have to be aware that we are doing 'something new'." (interview 7). "When the citizens of Amsterdam figure out that renovating the quay walls means completely rebuilding the walls, there will be resistance" (interview 7). The involvement of stakeholders might result in a smoother relationship between the project and the surrounding, avoiding resistance (interview 5).

6.2.2. Regulations and standards

Through the rest of the interviews, it became clear that the regulations are a big obstacle. "Because I think we should not underestimate the kind of struggle there is for the contracting authority to change regulations" (Interview 4). "The product must meet the regulated safety standards, and there is no way around that" (interview 6). In addition, changing these regulations includes an extensive validation process. "The item must sustain all four seasons; it has to be safe, measurements have to be conducted, which is an extensive process." (interview 6).

As mentioned earlier, the contracting authority prefers a proven object. "Authorities want certainty in advance for the object to fit within the regimes they employ." (interview 7). "An innovative product is only implemented when it has been proved 'ten times' (as a figure of speech), when the appointed authority approve the product, and when the maintenance department approves it." (interview 7). "A proven solution versus an innovative solution stand perpendicular to each other. So the regulations do not necessarily stimulate contracting authorities to include innovation in their contracts." (interview 9).

6.3. Summary

In this chapter, the output of the interviews about Innovation Partnership and barriers for innovation are summarized. Answering research question 5c; Innovation Partnership is experienced as a significantly different procedure. Describing recent experiences, the benefits of Innovation Partnership are that when a contracting authority chooses an Innovation Partnership, they show their will to innovate. Moreover, the procedure generates joint decision-making during the go/no-go moments and checks whether the technical and functional requirements are still met. On the other hand, Innovation Partnership is a lengthy procedure that requires a significant investment in the development phase for the contractor.

Barriers mentioned during the interviews are the uncertainty of profitability, short-cycle thinking, lack of capacity of resources, stakeholder readiness, and regulations. The regulations were one of the most often mentioned barriers. In addition, stakeholder readiness is a barrier that came forward during the interviews that did not occur, in those words, in the literature. Section 9.2.2 elaborates on this barrier and explains how Innovation Partnership can be a solution to this barrier.

7. Risk management for projects with innovation

Part of the interviews was a description of an unforeseen event related to product innovation they have experienced. Not all respondents had an example of an unforeseen event. In the end, seven events were described (section 7.3). Besides the description of the unforeseen events and how there were dealt with, the relation of innovations and risk management (section 7.1) and risk allocation in contracts (section 7.2) were discussed .

7.1. Risk management for project with innovation

The respondents were asked if, according to them, the risk allocation in projects with innovation should be different than in projects without product innovation. The general comments were that when innovating, the risks for the innovation part should be borne jointly. However, respondent 4 argued that if the contractor brought the innovation into the project and benefited from it, it should be their full responsibility. "In an ideal world, the contracting authority supports the use of innovation. However, that does not mean that the contract has to be adjusted. Instead, "the contractor should bring in an innovation because they benefit from it." (respondent 4).

When looking at a project where the contracting authority requests the innovation, the contracting authority should be more flexible when negotiating the risk allocation. Respondent 5 states that not only the risk allocation between the contractor and contracting authority is critical. Some risks cannot be borne by either one of the parties so, more important than the risk allocation is the way the risks are managed. "The risk allocation is the final framework." (respondent 5).

Respondent 6 highlights the difference in procedure for projects with innovation. The risk allocation for a project with innovation should be different. However, to establish this, there is the need for the contracting authority to change to a different procedure. The risk allocation can only be different if the project is procured differently from a project without innovation.

In interview 2, it was indicated that the risk allocation might not be different. However, the kind of risks is definitely different. "we are forced to, upfront, make a risk table: What can we expect to happen? Who is then financially responsible?" (interview 2). Comparing these risks to a regular UAV-GC project, where the responsibility allocations have been specified. Risks which are present when innovating are different".

7.2. Risk management in contracts

As part of the interviews, risk allocation was discussed. Risk allocation is part of the contractual agreement, and therefore, the interviews elaborated on some contracts. Most comments were about the UAV-GC 2012. In section 4.2 the UAV-GC is explained.

7.2.1. UAV-GC 2012

In the UAV-GC, the responsibilities for the contractor and the contracting authority are described in detail. Accordingly, respondent 4 thinks that the UAV-GC, in its current form, does not facilitate the option to innovate because it has been written down in too much detail. Interview 3 discussed that the UAV-GC offers guidance because it specifies the allocation of responsibilities in detail.

On the other hand, respondent 3 did also mention a limitation of the UAV-GC. "It creates a controlling environment. As the contracting authority, the focus shifts from the result to 'how can we check everything, so we are sure to get the result we want."(respondent 3). A significant downside to the UAV-GC is that the contracting authority awards the contract at a certain level, at the benchmark. Therefore, everything that goes differently than the benchmark is outside the contract. The contractor will be penalized for that. "that is not the right fit for an innovation process" (respondent 3). Respondent 8 argued that because of the fear of penalties, "a contractor will be less eager to try things out.".

Interview 8 also gave an example of the limitation of a UAV-GC. That was a project in which the contracting authority included possible innovations in their tender invitation. The tenderers could get a higher EMVI-score if they used one of these innovations in their tender. Even though the contracting authority proposed the ideas for innovations, all risks for the execution (including the innovation) were contractors' risks. If the contractor exceeded a milestone, they would be penalized. The contractor did not have the opportunity to utilize the innovation to its fullest extent because they feared the penalties. In the end, the structure of the project could have been slimmer and lighter. There was no possibility to include the improvements in the execution. "If it were a different contract, maybe this would not have happened." (respondent 8).

7.2.2. Other contracts

Respondent 9 mentioned a DBFM contract. He states that "a DBFM-contract can be interesting for innovation because of the long duration of the contract.". However, a limitation of a DBFM is that the risks mostly lay at the contractors' side (interview 6).

Contracts, where the contractor and the contracting authority can negotiate the allocation of the risks, include building teams, alliances, or collaboration agreements. These contracts should be introduced at the beginning of a project to utilize them fully (interview 8). Respondent 9 elaborated on the difference within a project. "For the part of the project that is very steady, the risks can be allocated to the contractor. However, the part which contains an obligation of means (in Dutch: inspanningsverplichting), an alliance (meaning: co-creation) is more suitable.".

7.3. Unforeseen events

This section answers sub-question 5b; How are unforeseen events managed in practice? An overview of the unforeseen events is given in table 7.1.

Table 7.1: Unforeseen events mentioned in the interviews, self made

	Innovation	Unforeseen event	Initiator of the innovation	Consequence for initiator	Responsibility of	Solution
1	First bored tunnel in the Netherlands.	**Technical** The bore machine shifted backwards because of failure of the jack pressure.	Contracting authority	**Delay** A standstill. Relatively unacceptable, caused financial loss and delay.	Contractor	**Transfer** Was solved through consultation between contractor and contracting authority.
2	Flexible noise barrier.	**Political** Barriers did not meet the regulations.	Supplier	**Not purchased** Supplier continued development	Supplier	**Avoid** Use of traditional barriers.
3	Concrete pile walls executed in clay/peat soil.	**Technical** Finding the right proportion of pouring concrete and pulling away formwork took a lot longer than expected.	Contracting authority	**Financial loss** Extra concrete was needed which resulted in extra costs and delays.	Contractor	**Accept** Keep trying till the right proportion was found.
4	Noise barrier build out of solar panels.	**Financial** No budget on the side of the contracting authority to apply in the project.	Contractor	**None** Was not an objective in the project, traditional barriers were applied	Contractor	**Accept** Use of traditional barriers.
5	Rejuvenation cream for asphalt.	**Technical** After applying the cream, the asphalt became very slippery.	Contractor	**Financial loss** Speed restrictions, extra nuisance for traffic.	Contractor	**Transfer** Speed reduction introduced in consultation with client, no financial consequences due to good cooperation.
6	Update of development of a damage detection system.	**Organizational** The update performed worse than an older version of the system.	Supplier	**Delay** Disappointing delivery to clients.	Supplier	**Accept** A lot of manual adjustments. Further updates will be done gradual.
7	A new system to dig breaches at the sea bet, 100 meters deep.	**Technical** The developed system could not handle the circumstances in which it had to function.	Contractor	**Financial loss** Budget and planning overruns.	Contractor	**Transfer** Activities were taken over by another contractors, no extension of the contract.

Based on the findings from the interviews, the ways unforeseen events are dealt with in practice depend on two variables: whether or not the success of the project depends on the innovation, whether or not the tender invitation included the innovation. The project number mentioned in the next paragraphs relate to the numbers in table 7.1

7.3.1. Project success depends on the innovation

The project success depends on the innovation when the project requirements can not be met without the innovation. The projects which depended on the innovation being successful are projects 1, 5, and 7. In project 1, the first bored tunnel in the Netherlands, the bore machine failed, so the project came to a standstill until the contractor fixed the problem. Project 5, rejuvenation cream for asphalt, resulted in hindrance for traffic, and therefore it caused penalties for the contractor. The innovation aimed to prolong the lifetime of the asphalt. It was part of the maintenance part of a DBFM contract. Therefore, it is debatable if the project would not have been successful without the innovation. However, the innovation was a significant part of the maintenance strategy. Project 7 entailed digging breaches in the see bed 100 meters deep. Digging these breaches was never done before when the project took place, and a new system had to be developed to execute the project. Without the innovation, the new system, they would not have been able to complete the project.

In projects where the innovation was not critical for the successful completion of the project, projects 2, 3, 4, and 6, the innovation was part of improving the quality of the final result or increasing productivity in the execution. Therefore, the contractor and contracting authority did not have an equal interest in the success of the innovation.

7.3.2. Innovation included in the tender invitation

When the innovation was part of the tender invitation, dealing with an unforeseen event was essential. Depending on the allocation of the responsibilities, the contractor and contracting authority deal with it. After signing the contract, the contractor must finish the project (Festen-Hoff et al., 2011) (unless agreed upon otherwise in the contract). For an innovation requested by a contracting authority, the contractor could have the possibility to share the risks with the contracting authority. However, how an unforeseen event is dealt with still depends on the allocation of risks in the contract.

An example of an innovation requested by the contracting authority is project 1. The contractor requested a bored tunnel in their tender invitation. It was the first bored tunnel in the Netherlands, and thus the first tunnel bored in Dutch soil, which appeared different from other countries. The awarded contractor brought in a tunnel boring machine delivered by a sub-contractor. This machine was already used in foreign countries but not in the Netherlands. Unfortunately, during the execution of the project, the machine back shifted because of the failure of the jack pressure. As a result, the project came to a standstill, and therefore the project was delayed by several days. The contract for this project was a bouwteam. Accordingly, the contractor and the contracting authority dealt with the financial losses through consultation.

When the innovation failed and was not part of the tender invitation, dealing with the unforeseen event was most likely the contractor's responsibility. An example of this is project 5, where the contractor submitted their offer, including the rejuvenation cream. However, because the asphalt became slippery after applying the cream, the speed limit was reduced, resulting in more lost vehicle hours (LVH), and exceeding the agreed-upon LVH results in penalties for the contractor. In this case, the cooperation between the contractor and the contracting authority was good enough that they worked it out without financial consequences.

7.3.3. Solutions for unforeseen events

The unforeseen events mentioned in the interviews all were resolved. The solutions to the unforeseen events deviated from not using the innovation to keep trying until the problem was fixed. The noise barriers, in both cases (projects 2 and 4), were not applied. During the execution, traditional noise barriers were placed. For projects 1 and 5, the first bored tunnel and the rejuvenation cream, the solution was found through consultation between the contractor and the contracting authority.

In project 3, the contractor could only finish the project by trying over and over. In this project, the contractor bore all the risk for the execution of the pile wall. However, there was a 'safety net'. When a committee composed by the contracting authority judged that the innovation became too big of a risk hazard, the contract could use traditional sheet piles. In project 7, where the contractor had to dig holes in a 100-meter deep-sea bet, the contractor got a contract for one hole. After this took way longer than planned and the system was not suitable for the circumstance, the contracting authority did not prolong the contract and awarded another contract to another party.

7.4. Summary

In this chapter, the findings for the interviews about the management of risks have been discussed. According to the interviews, it is established that different kinds of risks are managed in a project with innovation. Although innovation might be a critical part of the project, the contractor and the contracting authority must not forget that the innovation is part of a whole project.

Because the innovation is only part of the project, there should be a difference in the risk allocation for the innovation part of the project and the rest. For the innovation part of the project, the UAV-GC might not be the right fit. The primary limitations of the UAV-GC are that it is specified in detail, and there is no room for flexibility. For an Innovation Partnership, an UAV-GC is an option for the execution phase. During the development phase of an Innovation Partnership, however, a collaborative contract is more suitable.

Unforeseen events are dealt with through consultation between the contractor and the contracting authority. Answering sub-question 7.3, in practice, unforeseen events are dealt with when they arise. If the innovation is included in the tender invitation or project success depends on the innovation, dealing with an unforeseen event is critical for the contracting authority and the contractor.

8. Practical insights conclusion

This part of the report answered sub-question 5: How, in current practice, are innovations included in construction projects?

The need for innovation is indicated in the interviews. Challenges that require innovation are new PFAS regulations, national en European-wide circularity goals, Dutch nitrogen restrictions, and upcoming zero-emission execution of projects. The interview output indicated that the tender invitation should include innovation to stimulate the innovativeness of the market. At least, the contracting authority should utilize the innovative power of the market by disseminating the urgency for innovation. The contracting authority can do this through an Innovation Partnership. However, an Innovation Partnership can be a lengthy procedure when the innovation starts at a low TRL level. Stakeholder readiness, regulations and standards, are barriers to innovation, according to practice. For risk management of innovation-related risks, practical experiences indicate that the UAV-GC is too detailed. A more collaborative contract form (collaboration agreement, building team, alliance) is preferred.

Regarding unforeseen events related to innovation, these are dealt with between the contractor and the contracting authority when they occur. Upfront, there was no specification of coping with unforeseen events. Answering the question, innovation is included in construction projects:

- by the contracting authority when they indicate the urgency for innovation in their tender invitation.
- when the project is procured by an Innovation Partnership, indicating the innovative intention of the contracting authority.
- by sharing risks through collaborative contracts.

III
Results and validation

Introduction

In part I and part II, the literature and the practical experiences through interviews are explained. This part analyses the differences and similarities between literature and the interviews. The analysis is conducted to be able to include practical experiences and established literature in the answer to the main question.

Figure 8.1: Part 3 - Results and validation (Full scheme see figure 1.2)

Following the structure of part I and part II, the analysis is divided into three subjects. The first chapter (chapter 9) goes into detail about the need for innovation and the inclusion of innovation in the procurement procedures. Chapter 9.2 elaborates on the Innovation Partnership procedure and the barriers for innovation. The third section, section 9.3 includes the differences and similarities between literature and practice in dealing with unforeseen events and establishing what risks should be managed. The report structure is visualized in figure 8.2

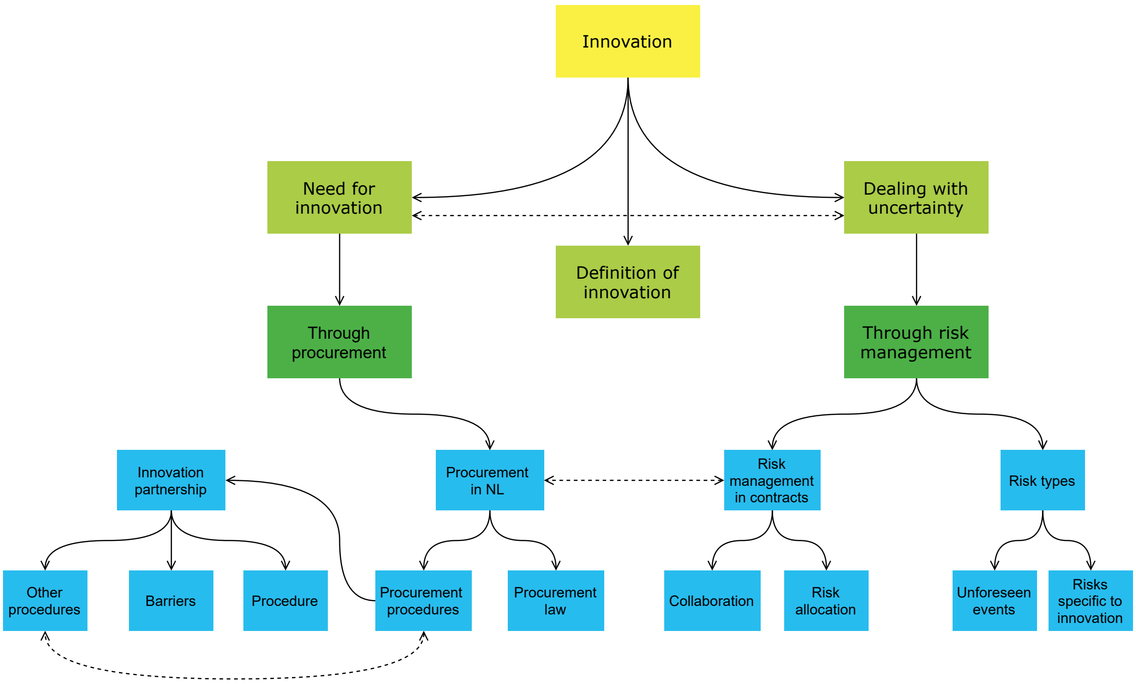

Figure 8.2: Part structure

Validation

To validate the outcomes of the interviews and the conclusions, an expert session was conducted. The perspective of three experts in the area of procurement on contracting authorities side, tender management on contractors side, and contract management was gained through ten statements. The choice for these experts is based on the main subjects of this research: procurement and risk management for project including product innovation. Herein, the expert on contract management has a clear vision on risk allocation, and the procurement and tender experts represent the two sides of a procurement process; the contracting authority and contractor respectively.

In appendix C the hand-outs with the statements are shown. After a brief introduction into the research, the experts were asked to indicate to what extend they agreed or disagreed with the statements and motive there opinion accordingly. Moreover, the expert had no prior insight into the content of the statements to prevent prejudice. The validation session was one group session so that the experts could react on each other and discussed their point of view. The composition of the statements was based on the results from the interviews. Two statements were related to the need for innovation in the construction industry and the inclusion of innovation in the tender invitation of the contracting authority. Statement 3 till 6 discussed the Innovation Partnership and the barriers of innovation, and statement 7a till 9 included risks management in projects that include innovation.

The experts could indicate how far they agreed or disagreed with the statement. By introducing this gliding scale, nuances could be included in the discussion. The nuances and comments of the experts are included in the next chapter, chapter 9.

9. Results

9.1. Indication of innovation urgency

The need for innovation is emphasized in literature and practice. As explained in section 2.2 and 5.1, the sustainability and circularity goals and the new regulations for nitrogen and PFAS are drivers to be innovative. The interviews indicated that the need to innovate stimulates the innovation power of the market as long a the contracting authority suggests the urgency for innovation in their projects. Following the literature, when the contracting authority requests an innovation, it can be described as a demand-pull situation (Rothwell, 1994). However, it is most likely that the innovations requested by the contracting authority are incremental (Dodgson et al., 2008). Because "they [the contracting authority] already know what works" (interview 7).

In the validation, the experts were asked to what extent they agreed with the statement: "When the contracting authority indicates the need for innovation, it stimulates the innovativeness of the market parties.". The contract manager and the procurement expert agreed with the statement. However, the tender manager disagreed. He argued that the market parties' innovativeness highly depends on the award that relates to the indication of the need for innovation. The projects, most of the time, are awarded based on price and quality. Therefore, when the contractor includes innovation in their offer, the price will probably be higher. So, the indication of the urgency of innovation does stimulate the innovativeness of the contractors, as long as the urgency comes with a suitable reward. The project must be a profitable business case of the contractor.

9.1.1. Including innovation in procurement procedures

A way to deal with innovation is through procurement. When innovation is included in the tender invitation of the contracting authority (demand-pull), this stimulates the innovation power of the market. Both literature and the interviews agreed on that. For the contracting authority, their need to innovate is answered through procurement because including innovation in the tender invitation facilitates the search for the missing knowledge of the contracting authority, and the market parties have the opportunity to propose innovative solutions (Schilling, 2018).

9.2. The Innovation Partnership

The Innovation Partnership procedure is described in section 3.1. In the interviews, benefits and disadvantages were discussed; see chapter 6. Here the combined findings are elaborated on.

9.2.1. The procedure

The development of the innovation is included in the procedure. Depending on the TRL-level requested in the tender invitation, the procedure can be lengthy. In the interviews, the duration of an Innovation Partnership was indicated as a disadvantage. However, the duration of the procedure depends on the design of the procedure.

Duration

The use of an Innovation Partnership shows the intention of the contracting authority to innovate. In this, the Innovation Partnership frames the will to innovate into a challenge. Despite the availability of the Innovation Partnership procedure, not every project where an innovation is requestd is suitable to be procured through and an Innovation Partnership. As described in section 3.2, Innovation Partnership is suitable for a project where the contracting authority wants to innovate with a TRL starting level 4 to 8 (Eadie & Potts, 2016). Level 4 being Component validation in a laboratory environment, and level 8; Actual system completion through testing and demonstration (Mai, 2017). The TRL-level where the innovation starts at influences the duration of the procedure.

Therefore, an Innovation Partnership can be a lengthy procedure when the innovation includes many TRL-levels still to be taken.

The duration of the procedure also depends on how the procedure is designed. Also, it depends on the time advantage the innovation results in. An Innovation Partnership includes the development of an innovation and the execution of the project. When the innovation speeds up the execution, the time used in the innovation development is compensated in the execution.

Another advantage of the length of the procedure is the possibility to test the innovation to make sure it complies with standards and regulations. Standards and regulations are identified to be barriers to innovation. The barriers to innovation are discussed further down in this section.

Contracting authority's intention

In the interviews, it has been indicated that when a contracting authority procures a project through an Innovation Partnership, their incentive to innovate is obvious. That the Innovation Partnership shows the contracting auhtority's incentive to innovate is emphasized in the expert session. The indication of the innovation incentive of the contracting authority deals with one of the barriers described in section 3.3: "the missing incentive for suppliers of innovative solutions" (Uyarra et al., 2014) and with that, "the lack of recognition of the value of innovation." (Gambatese & Hallowell, 2011).

9.2.2. Recognized barriers for innovation

In section 3.3 and section 6.2, the barriers to innovate in the construction industry are indicated. The following barriers are further discussed here: standards and regulations and stakeholder readiness. The fact that a new product must comply with traditional standards and regulations was the most mentioned barrier. Stakeholder readiness was identified through the interviews.

Regulations and standards

After comparing the barriers mentioned in the literature (section 3.3) and the barriers mentioned in the interviews (section 6.2 it is evident that the regulations and standards applied to the technical specifications of an innovation (Blayse & Manley, 2004; Gambatese & Hallowell, 2011) are, at this point, the most significant barrier experienced. That standards and regulations are significant barriers is recognized during the validation. Even though the experts agreed with the statement, they also recognized the need for the regulations. Letting the regulations and stands go is not an option as they ensure safety and quality. As mentioned earlier, the length of an Innovation Partnership can help overcome this barrier. Because testing and validation of the innovation are included in the procedure, it facilitates the time and resources needed to 'prove' that the innovation complies with standards and regulations.

The European and Dutch procurement law elaborate on this subject. In article 2a.39 of the Dutch procurement law (Government of the Netherlands, 2012), and the European procurement law (European Commission, 2014) article 42.5 is stated that an innovation will not be rejected by the contracting authority as long as the tenderer, proves that the innovation compiles, in an equivalent manner, to the technical and functional requirements. Proving this, however, takes time and has financial consequences.

Stakeholder readiness

Sections 3.3 and 6.2 also indicate the need for stakeholder management in the development of an innovation. Stakeholder readiness translates into: the readiness of stakeholders, without control, for the implementation of the innovation (interview 5). "Key players," "context setters," and "subjects," explained in chapter 3 have to be on board and ready for the innovation to prevent resistance. Some of these stakeholders have been used to doing activities in the same way for years. They should therefore be engaged prior to, during, and in the project.

In the expert session, it was emphasized that those stakeholders are important. An innovation is only successful when the end-user thinks it is successful. However, to some extent, the future owner can impose the innovation that manages the operators.

9.3. Risk management

In a project including innovation, there is more uncertainty because it has never been done before. Risk management deals with future uncertainties through contractual agreements. Section 2.5 explains the process of risk management in projects.

According to the interviews, risks management in projects with innovation differs to some extent. The respondents indicated that innovation is part of an entire project and should be managed accordingly. In the validation, the procurement expert did not agree to that. He argued that even though the innovation is part of the project, risk occurring related to the innovation can also influence the rest of the project. Therefore, the innovation part of the project and the rest of the project should be seen as one.

On the other hand, the tender expert agreed that the contractor and the contracting authority should manage the risks related to the innovation differently. He argued that because the innovation has not proven itself, there is more uncertainty, and therefore, the risks should be allocated differently.

9.3.1. Handling unforeseen events

In the interviews, the respondents elaborated on unforeseen events they had experienced. Section 7.3 has summarized the events and found two main variables that can influence the way unforeseen events related to innovation are managed in a project. Firstly, variable one distinguishes a difference between whether or not the project's success depends on the innovation. Secondly, the second variable establishes a difference between the contracting authority requesting an innovation in their tender invitation (demand-pull) or the contractor proposing a solution including an innovation (technology-push).

In the described unforeseen events, the damages were covered according to the contracts. In the cases that the innovation was the contractors' responsibility, the contractor was the one that had to bear the consequence of an unforeseen event. For both variables, this was similar. Even though a contracting authority requests an innovation in their tender invitation, the execution of the innovation will be (depending on the contract) the contractor's responsibility.

On the other hand, in the validation session, the experts agreed that an agreement has to be made upfront for when unforeseen events occur. The validation identified no difference between the different variables. However, the contract manager indicated that with a procurement procedure where meetings, negotiations, or dialogues are included, the contractor has the chance to negotiate the ownership of the risks. In an Innovation Partnership, there is the possibility to discuss the ownership of risks.

9.3.2. Suitable risk allocation

In section 2.5, several types of contracts are elaborated upon. In the interviews (see section 7.2), the most mentioned contract form was the UAV-GC. As can be seen in the literature, the risk allocation in the UAV-GC is specified in detail. The interviewees indicated that that causes the UAV-GC not to be suitable for a project where innovation is included.

In the validation, the experts made nuances. An UAV-GC is deemed suitable for the execution of a project that includes an innovation. However, for the development of the innovation, a more jointed contract would be better feasible. An Innovation Partnership facilitates the use of separate contracts in the research and development phase and the execution phase. Combining literature and practice with regards to risks management, a suitable allocation of risks can be defined for four project phases: problem definition, research and development, and design, execution, maintenance, and operations. In the following paragraphs for each project phase, the allocation and joint responsibilities are set out.

Problem definition (prior to the tender invitation)

The contracting authority identifies the problem for which they seek a solution and assesses the TRL-level of the required innovation. Depending on the TRL-level, the requirements in the tender invitation will be more technical (high TRL-level) or functional (low TRL-level) specified (Eadie & Potts, 2016).

The contracting authority wants to create a technology push innovation process to stimulate radical innovation to overcome traditional thinking and to support the transition that is going on in the construction industry to achieve the circular construction economy in 2050 (Rogers, 2003; Lodder et al., 2017). Therefore, to create a technology-push environment, the contracting authority should only specify the problem and compose functional requirements (PIANOo, 2017).

During the problem definition phase, the contractor prepares their submission, (optionally) forms a consortium to develop the innovation, and designs and develops the innovation to the TRL-level requested in the tender invitation.

The contractor and the contracting authority do not share risks at this stage because they have not entered into a contractual agreement with each other. Table 9.1 shows the responsibilities of each party. The bold markings are responsibilities or activities which are specific to an innovation project.

Table 9.1: Responsibilities problem definition

Contracting authority	Contractor
• Definition of the problem • **Identification of the need for innovation**	• **Development of innovation (problem solution) to meet the selection criteria** • **(optional) Find consortium parties** • Compose tender
Liable for: • *Content of their requirements, even after change or completion following the contract formation*	*Liable for:* • *Submitted tender*

Design, research and development

In the design phase of the project (for an Innovation Partnership, this phase includes research and development of the innovation), there are many unknowns and uncertainties because of the novelty of the product (Loch et al., 2008; Rogers, 2003). To overcome the risk aversion, an alliance should be formed to manage the losses and gains collaboratively. Table 9.2 indicates the joint responsibilities for the contractor and the contracting authority. An alliance is the most suitable contract model for the research and development phase of an Innovation Partnership because the contractor and the contracting authority can jointly establish specifications, define the project goal, can share risks where needed (Teng, 2007).

Table 9.2: Responsibilities research and development

Contracting authority Alliance agreement	**Contractor**	**Joint responsibility**

• **Monitoring progress of innovation development**
• **Set up milestones for go/no-go moments**
• **Set functional and technical requirements in consultation with the alliance**
• Deliver information relevant to the contractor that they have at their disposal
• Provide all the goods specified in the agreement
	• **Development of the innovation from starting TRL-level up until TRL 9**
	• **Make innovation in accordance with agreed-upon functional and technical requirements**
	• **Make innovation in accordance with standards and regulations**
	• Make a design fit for purpose and in accordance with ‘normal’ and ‘explicitly’ stated requirements
		Set up alliance contract including:
		• Define project goal
		• Establish technical and functional requirements for the innovation
		• Agree upon ownership of the Intellectual Property Rights (IPR):
		  o The contracting authority owns IPR
		  o The contractor owns IPR
		• Allocate risks to specific parties and establish which risks are borne through the alliance
		• Set up alliance fund

Liable for: • ***Validation and verification of specifications for go/no-go moments*** • *Damage due to any late or incorrect provided information or other defects or errors relating to the information, land or water, and goods*	*Liable for:* • ***Development of the innovation in accordance with agreed-upon specifications***	

As discussed in section 4.2 whether a risks will be allocated to the contractor or the contracting authority, or to the alliance depends or the influence a party has on the risk and if a party has the resources to manage the risks. The four categories identified are:

1. Risks can be influenced and borne by both parties; decisions for the design
2. Risks can be influenced and borne by only one party;
3. Risks can not be influenced by and can not be borne by either party; environmental disasters, weather, inflation
4. Risks can not be influenced by and can not be borne by either party but the risk only impacts one party; changes in regulations, strikes

The Ownership of the IPR can influence the willingness of the different parties to contribute to the management of risks related to the innovation. In an alliance, the intellectual property rights can be managed as follows:

- Contracting authority owns IPR; by buying off the right from the other alliance parties (Teng, 2007).
- Contractor owns IPR; This is an alternative where the contracting authority receive a license for the use and maintenance of the product (PIANOo, n.d.-a).

For an Innovation Partnership, it is beneficial for the contracting authority when the contractor owns the intellectual property rights because he is less dependent on a contractor for their innovation when multiple contractors are awarded a contract (PIANOo, n.d.-a).

Execution

The execution starts after the design, research and development phase is completed. Thus, the level of uncertainty related to the innovation is reduced (Stosic et al., 2017). However, because the innovation is a new product, unforeseen events have a higher probability of occurring (Loch et al., 2008; De Fátima Segger Macri Russo et al., 2013). Therefore, the execution of the project can proceed governed by the general condition of the UAV-GC with an exception to risks related to the innovation. In addition to the UAV-GC, an added module should assure sharing of losses and gains through the alliance fund to manage unforeseen events. This addition to the UAV-GC prevents the contractor from bearing all the risks of the project and the innovation.

The alliance agreement used for the research and development can be extended into the execution phase solely to serve the risks related to the innovation. Which risks are included in this agreement can be negotiated during the composition of the contract. Whenever a risk related to the innovation occurs, the contractor and contracting authority can assess the risk jointly and determine who is the responsible party or if the risk is jointly borne through the alliance fund. Table 9.3 show the responsibilities of the contracting authority and the contractor during the execution phase.

Table 9.3: Responsibilities execution

Contracting authority UAV-GC + Alliance module	**Contractor**	**Joint responsibility**
• **Validate innovation** • Deliver information relevant to the contractor that they have at their disposal	• **Execution of the project, including the innovation** • **Monitor and report risks related to the innovation** • Execution of the design in accordance with the requirements set by the contracting authority • Informing the contracting authority on quality insurance	Risks related to the innovation (including unforeseen events): • All risks occurring related to the innovation are borne together through the alliance fund, or; • Every innovation-related risk is assessed and allocated based on a party's influence and manageability
Liable for: • ***Validation of the innovation*** • ***Changes to the contract or requirements, not related to the innovation given by the contracting authority***	*Liable for:* • ***Correct execution of the innovation*** • *" defects": deviation of the contracting authroity's requirements*	

Maintenance and operation

After the execution and delivery of the project, the innovation (and the rest of the project) is put into use. The innovation is only transferred to the future owner when the innovation is validated and functions in accordance with the specifications. Depending on the contract, the maintenance and operation are included in the contract (DBFM(O) contract), or maintenance and operation are the government's responsibility (in the role of the future owner). The future owner can, in their turn, outsource the maintenance and operations of the work, yet this is not included in the scope of this research. At this stage of the project, the allocation of risks does not differ from a project with no innovation included.

The remaining joint responsibilities of the contractor and the contracting authority are any failure related to the innovation that is proven to be caused during the design, research and development, or execution of the innovation.

Table 9.4: Responsibilities maintenance and operations

<table>
<tr><th>Future owner
From contractor transferred to future owner</th><th>Contractor</th><th>Joint responsibilities</th></tr>
<tr><td>Maintenance of innovation following contractors’ instructions
Inspection of the works
Acceptance of the work</td><td></td><td rowspan="2">When the innovation fails, or there is a failure related to the innovation and it is proven to be caused by the contractor or the contracting authority during:
Execution, or
Research and development, or
Design
The alliance module come back into place, and the consequences are borne following that agreement.</td></tr>
<tr><td>Liable for:
The work after completion unless maintenance and operations is outsourced</td><td>Liable for:
The contractor is no longer liable for defects in the works unless:
Maintenance is part of the contract
The defects are the fault of the contractor, or it is their responsibility, and
The contracting authority did not notice these defects prior to completion and acceptance, and
The contracting authority could not reasonably have detected the defect at the time of acceptance of the work.</td></tr>
</table>

9.3.3. Risk sharing

As explained in section 4.2 risk sharing is not self-evident. Depending on the manageability and the influences a party has on the risks, the risks are allocated to the specific party or are allocated to the alliance. The risks assigned to the alliance are managed by using the alliance fund. Risks allocated to the alliance are the risks that cannot be borne or influenced by either party, these should be insured or risks that can be borne and influenced by both parties. Risks that can only be influenced or borne by one specific party should be allocated to that party.

IV
Conclusion

10. Discussion

This research aimed to expand the knowledge about the Innovation Partnership and determine how unforeseeable uncertainty related to innovation is handled in the construction industry. The results indicate that the Innovation Partnership procedure can be a lengthy procedure, depending on the TRL-level of the developed innovation. Furthermore, the procedure handles barriers indicated by literature and practice such as: "the lack of recognition of the value of innovation" (Gambatese & Hallowell, 2011), "the missing incentive for suppliers to submit innovative solutions"(Uyarra et al., 2014), and "stakeholder readiness" a barrier mentioned in the interviews. Another barrier to innovation in the construction industry is dealing with the regulations and standards set by the authorities.

The allocation of risks is arranged in contractual agreements. When innovation is included in a project, the risks relating to the innovation can not all be identified upfront because of the novelty of the product (Loch et al., 2008; Rogers, 2003). Therefore, unforeseeable uncertainty must be dealt with. In practice, it appeared that coping with unforeseen events related to product innovation is not currently a problem. However, it has been identified in the literature and the validation of the results. Therefore, the contractor and the contracting authority should separate risk allocation for risks related to product innovation between risks associated with the development of an innovation and risks associated with the implementation of an innovation. During the development of an innovation, more uncertainties occur, whereas, during the execution, the innovation is less uncertain (because the innovation has been tested and proven)(Stosic et al., 2017).

In the discussion, the interpretations of the results and the limitations of the research are discussed. Following the report's structure, the interpretations relate to innovation in general, the Innovation Partnership, and risks for projects with innovation. The limitations include limitations to the research content and the research methodology. The discussion is followed by the conclusion of the research and the recommendations in chapter 11.

10.1. Interpretations

Innovation

Adding to the literature study of this research, including innovation in a project is not only needed for the sustainability and circularity goals. Innovation can also benefit the contracting authority and the contract themselves. The benefits innovation has on the contractor and the contracting authority might contradict the interview statement that implementing an innovation is more successful when included in the tender invitation.

The Innovation Partnership

The results suggest that the Innovation Partnership is the best approach to innovate in the construction industry. However, it should be noted that other procurement procedures can facilitate innovation as well (Chao, 2014; Procurement of innovation platform, 2014). The interviews and the validation session highlighted that innovation could be implemented using all kinds of procurement procedures. However, an Innovation Partnership creates a technology push environment, whereas a demand-pull innovation process is introduced in other procedures.

The "idea" that an Innovation Partnership is a lengthy procedure might not be entirely accurate. The length of the procedure depends on the TRL-level of the requested innovation. Also, the validation indicated that because the procedure includes the R&D phase, that part might take longer than other procedures, but the duration is leveled if the innovation reduces execution time. Also, it offers the possibility to test an innovation to comply with standards and regulations.

Uncertainty of innovation

An unexpected result of the research was the lack of relevance to deal with unforeseen events in practice. The extent to which these results contradict the literature is that dealing with unforeseen uncertainty has an operational outcome. When the unforeseen event occurs, the contract will be looked at, and the contracting authority and the contractor will try to find the source of the event. Then, whoever is responsible for that part of the project, will be responsible for the unforeseen event.

Risk allocation

In the end, it has been established that the UAV-GC does facilitate the implementation of innovation in the execution. With this, a fundamental realization is that the innovation is only one part of the project. When the innovation is the central part of the project, the UAV-GC will probably not be suitable. Then the alliance should be a project alliance of the whole duration of the project.

10.2. Limitations

Limitation to the research

- The scope of this research was limited to the construction industry. Therefore, the results are only applicable for construction projects. The results can be used in other sectors. However, the structure of a project and the way of working might vary from the construction sector.
- The cultural change needed for a gain- and risk-sharing environment is not included in the research. However, the cultural values of Dutch people might influence the success of an alliance agreement.

Limitations of the research methodology

- The practical insights were gathered through interviews. In addition, detailed case studies could have identified a specific problem with the Innovation Partnership or the inclusion of innovation in a project. However, by using the interviews, the results were more generalized. Therefore, the results can be applied on more occasions.
- Because of the extensive literature on innovation, procurement, and risk management, not all existing literature could be included in this research. Therefore, the selection of literature used in this report, is the most relevant literature because of the citations and their applicability to the research objective.
- Time limitations influence the number of experts included in the validation session. Because the experts were selected based on their experience with the three subjects of this research, either three experts should have joint (one for each subject) or six experts had to be found (two for each subject).
- Detailed case studies could have established an in-depth understanding of how the Innovation Partnerships currently active in the Netherlands are designed and how the risks management is arranged in these projects. However, by not conducting the case studies, unbiased recommendations are made.

11. Conclusion and recommendations

11.1. Conclusion

This research aimed to determine how risks related to product innovations should be managed in projects procured through an Innovation Partnership in the construction industry. To meet with future sustainability circularity regulations and to be able to renovate and replace existing infrastructure, innovation is crucial. However, introducing innovation in a construction project comes with challenges. Questions that arose were: how can product innovations be procured? How can the uncertainties related to the development of innovations be managed? And how can risk aversion be overcome? These questions were gatherer in the main question of this research:

*How can an **Innovation Partnership** stimulate **innovation** in the construction industry by dealing with **uncertainties** related to product innovation?*

The answer to the main research question is given at the end of this chapter. The answer is based on the answers to five sub-questions, presented in the introduction of the research. The answers to the sub-questions are stated in the following section.

11.1.1. Sub-questions

- Sub-question 1: How does the procurement of innovation facilitate the need for innovation in construction projects?

  There are two ways to include product innovations in a construction project: (1) the inclusion of innovation in a project is done through a demand-pull process: the contractor requests innovation in their tender invitation. Alternatively, (2) innovation is included through a technology-push process: the contractor proposing an innovation as a solution to the problem stated in the tender invitation of the contracting authority. A demand-pull innovation

  process is less uncertain for a contractor because the contracting authority intends to purchase the developed product. However, a demand-pull innovation process results in more incremental innovations because the innovation is based on specific requirements of the contracting authority. To facilitate the transition that the construction requires, radical innovations are needed. Therefore, the contracting authority should specify the needed innovation with a minimum number of requirements, and the requirements should be drawn up in a functional manner.

- Sub-question 2: What type of uncertainties relate to innovation in construction projects?

  In the construction industry, two types of uncertainties are distinguished: foreseeable uncertainty and unforeseeable uncertainty (Loch et al., 2008). Foreseeable uncertainties are dealt with through risk management. The general approach is to identify the risks, assess the risks, and allocate the risks (Nicholas & Steyn, 2017). When a product innovation is included in the project, not all risks can be identified upfront. The novelty of the product innovation hinders the upfront identification of risks. Therefore, the development of and product innovation introduces more unforeseeable uncertainty (Rogers, 2003; Schilling, 2018).

- Sub-question 3: How does the Innovation Partnership deal with barriers to the implementation of product innovations in construction projects?

  By using the Innovation Partnership to procure a project, the following four barriers for innovation are covered:

- **Recognition of the value of innovation**: the contracting authority will only use an Innovation Partnership when they recognize that an innovation adds value to the project.
- **Incentive to come up with innovative solutions**: the contracting authority indicates the need for innovation in the project. That creates the incentive for the market to come up with innovative solutions.
- **Standards and regulations**: products that are traded on the market, need to meet specific safety and quality standards and regulations. The government sets up these standards and regulations, and they are strict to ensure safety and quality. For the development of a new product, the standards and regulations can form a hindrance when the product innovation does not meet them. The standards and regulations can be adjusted whenever the product innovation proves to meet the functional requirements of the standards and regulations. To prove this, the product innovations must be tested in a relevant environment. The long duration of a testing period forms a barrier to implementing a product innovation. Testing the innovation is one of the steps of the TRL-ladder (Technology Readiness Level). During the R&D phase of an Innovation Partnership, the innovation will be developed in accordance with the TRL-ladder. Therefore, testing the product is included in the R&D phase of the Innovation Partnership.
- **Stakeholder readiness**: an Innovation Partnership facilitates the possibility to engage and involve stakeholders from in an early stage of the project. Whenever stakeholders are not ready for the innovation, it can cause resistance. The readiness of stakeholders can be improved by informing and engaging them prior to and during the development and implementation of the product innovation in the project.

• Sub-question 4: How does the use of product innovation in a project affect the way risks and uncertainties related to innovation are managed in a project?

The main difference between a project that includes an innovation, and a project not including an innovation, is the level of uncertainty. Because innovations bring higher levels of uncertainties, mainly during the R&D, sharing losses and profits is beneficial for the radicalness of the product innovation, because it overcomes risk aversion. In the answer to the main question, the allocation of risks is specified in four project phases. This specificationcan be found in the next section.

• Sub-question 5: How, in current practice, are innovations included in construction projects?

The output from the interviews conducted for this research indicated that the tender invitation should include innovation to stimulate the innovativeness of the market. At least, the contracting authority should utilize the innovative power of the market by disseminating the urgency for innovation. The contracting authority can do this through, among other procedures, an Innovation Partnership. However, an Innovation Partnership can be a lengthy procedure whenever the innovation starts at a low TRL-level. Stakeholder readiness, regulations and standards, are barriers to innovation recognized by practice. For risk management of innovation-related risks, practical experiences indicate that the UAV-GC is too detailed. A more collaborative way of risk-bearing is preferred. However, the interviews also indicated that it should be recognized that the innovation is only part of the project, and the project it self is not perse more uncertain.

Answering the sub-question, innovation is included in construction projects:

- by the contracting authority when they indicate the urgency for innovation in their tender invitation.
- when the project is procured by using an Innovation Partnership, indicating the innovative intention of the contracting authority.
- by sharing risks through collaborative contracts.

11.1.2. Main research question

The answers to the five sub-question are combined to formulate answers to the main research question. To stimulate innovation through an Innovation Partnership, the uncertainties related to technological product innovations should be managed following the level of uncertainties of the product innovation in the specific project stages. The level of uncertainty surrounding the product innovation reduces after the R&D phase of the Innovation Partnership. The following paragraphs elaborate on risk allocation in four project phases in an Innovation Partnership.

The four phases identified are: problem definition phase, R&D and design phase, execution phase, and maintenance and operation phase. As mentioned earlier, each phase requires a specific approach for risk management:

- Problem definition phase; Contracting authority formulates the tender invitation for which they are liable. The tender invitation should include a minimal number of functional specifications to stimulate radical innovation proposed by the market. Here, there are no shared responsibilities.
- Design and R&D phase; Contracting authority and contractor form a design alliance in which profits and losses are shared through the use of an alliance fund. In the R&D phase, the uncertainties related to the innovation are the highest. Shared responsibilities include the definition of the project goal, agree upon intellectual property rights, set up alliance fund, negotiate what risks are allocated and what risks are shared.
- Execution phase; The risks in the execution phase of a project including a product innovation consists of two parts: (1) risks related to the general project and (2) risks related to the product innovation. Because the innovation is developed and tested during the R&D phase, uncertainty with the innovation is reduced. Therefore, the project in general can be executed by using an UAV-GC. In addition to the execution contract, an alliance module should be added to cover the risks that relate to the product innovation. Joint responsibilities in this phase include risks related to the product innovation.
- Maintenance and operation; With the maintenance and operation phase, the responsibilities of the innovation are transferred to the future owner of the project. The contractor and the contracting authority can only be held liable when a defect occurs that is proven to be caused during the execution phase or the R&D phase.

In an alliance, the losses and profits are shared by introducing an alliance fund. The alliance fund performs as an equalizer for the way profits are made for the contractor and the contracting authority. The risks shared in the alliance through the alliance fund include:

- Risks that can be borne and influenced by both parties and;
- Risks that can not be borne and influenced by either party, these risks should be insured

Whenever a risk can only be borne or influenced by one specific party, the risk should be allocated to that specific party. For example:

- Contracting authority's risks include, among other, risks related to: permits, allowances, building location
- Contractors risks include, among other, risks related to: contractors errors, sub-contractors errors
- Alliance risks: design flaws, supply disruptions, environmental disasters, change of regulations.

Risks that can be managed by one specific party in the alliance can be kept outside of the alliance. However, the essence of an alliance is that the risks are managed jointly (Boot et al., 2012).

11.2. Recommendations

Based on the research findings, some practical recommendations are made. Furthermore, the research proposes recommendations for future research.

11.2.1. Recommendations for practice

Based on the conclusion of this research, the following recommendations are made:

Innovation

- Both the contractor and the contracting authority should acknowledge that a continuous innovation process is beneficial:
  - For contractor; development of innovation should be done internally to keep up with the evolving requirements set by authorities. Furthermore, the internal development of innovation can create a competitive advantage and increase distinctiveness.
  - For contracting authority; to meet future legislation and increase the project's efficiency and quality.

The Innovation Partnership

- To prevent resistance from operators and organizations that are not ready for change, it is essential to engage them in the project in an early stage of the project for the duration of the project.
- When including innovation in the tender invitation, the contracting authority should minimize the number of requirements and formulate the requirements in a functional nature. The number of requirements directly affects the level of radicalness of the innovation that the market will include in their submission.

Risk management

- Risks and gains related to the innovation should be shared between the contractor and the contracting authority in the research and development phase and the execution:
  - Research and Development: to overcome risk aversion and fear of significant loss, the contractor and contracting authority form an alliance. The R&D phase contains the most uncertainties.
  - Execution: the execution of the project can be done through an integrated contract model governed by the UAV-GC with an addition of an alliance for all risks related to the product innovation.

11.2.2. Recommendations for further research

- This research is generalized; It would be interesting to know the difference between small (e.g. municipalities) or big (e.g. Rijkswaterstaat) governments. Here the difference in (financial) resources to include innovation in projects differ, and the differences in organizational culture can influence the implementation of innovation in projects.
- A comparison of the Dutch or European construction industry to construction industries under different procurement laws on the level of innovation inclusion, to indicate if the Dutch or European procurement law is sufficient. Also, in the Netherlands, there is no commonly used standard for alliance agreements. Other countries do have these standards. Therefore, indicating how other cultures design alliances can be used to propose an alliance standard for the Netherlands.

- A research on the lessons learned from completed Innovation Partnerships. That research could elaborate on the knowledge about the procedure, and where needed, improve the procedure. Because, so far, only a few projects in the Dutch construction industry are procured through an Innovation Partnership, in the future, the lessons learned from these projects can be used to optimize the design of the Innovation Partnership.
- This research assumed the construction phases in subsequent order. However, because an Innovation Partnership can be is part of a larger program, the chances are that one project contains multiple project areas where different product innovations are implemented. Then, the possibility arises that one part starts execution while another part is in the research and development phase. That results in a complex system of contracts. Therefore, a research can be conducted to optimize contractual agreements for projects, including parallel project phases.

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A. Interview questions

This appendix contains the interview questions. The outcome of the interviews is elaborated on in part II. The interview questions are composed in Dutch to fit the audience. Every respondent spoke Dutch.

Deel 1: 10 min

Eigen Introductie (5 min)

Onderwerp	Vragen/opmerking	Doel
Persoonlijke achtergrond	CME afstudeerder bij Flux partners Waarom keuze voor geïnterviewde?	Kennismaking
Toestemming opname en vertrouwelijkheid kenbaar maken	Uw gegevens worden vertrouwelijk behandeld en komen anoniem terug in de algemene rapportage van het onderzoek. Opname van het gesprek dient voor mij om het terug te luisteren zodat uw waardevolle antwoorden niet verloren gaan. Na transcriptie wordt deze verwijderd.	Toestemming voor opname
Samenvatting onderzoek, doel van het interview	Doel onderzoek: vaststellen hoe het omgaan met onvoorziene gebeurtenissen wordt meegenomen in het innovatiepartnerschap. Doel interview: praktijkkennis opdoen over onvoorziene gebeurtenissen in projecten waar een productinnovatie wordt toegepast	Verduidelijking van onderzoek en bijdrage interview
Definitie van productinnovatie	De definitie van productinnovatie die in dit onderzoek wordt gebruikt: een productinnovatie is een nieuw of significant verbeterd product welke productiviteit en/of kwaliteit van de projectuitkomst verbeterd.	Creëren van een gezamenlijke werkdefinitie om te zorgen dat we over het zelfde praten

Introductie respondent (5 min)

Onderwerp	Vragen	Doel
Achtergrond en Functie respondent	1. Wat is uw professionele achtergrond? 2. Wat is uw huidige functie? 3. Hoe veel jaren ervaring heeft u in deze functie?	Ervaring respondent samenvatten ter validatie interview uitkomsten.
Betrokkenheid realisatiefase van projecten	4. Hoeveel ervaring heeft u met projecten waar productinnovaties worden toegepast? 5. In welke fase van het project start uw betrokkenheid bij een project en wanneer eindigt uw betrokkenheid? In uw huidige functie. 6. Wat hield uw betrokkenheid in? 7. Verschilt de mate waarin u betrokken bent gedurende de looptijd van het project, of bent u in de gehele looptijd gelijkmatig betrokken?	Bepalen in hoeverre de respondent betrokken is bij welke fase van de innovatie.

Deel 2: Hindernissen, onzekerheden en onvoorziene gebeurtenissen (40 min)

Stelling 1: Onvoorziene gebeurtenissen horen bij innoveren

<table>
<tr><th>Onderwerp</th><th colspan="2">Vragen</th><th>Doel</th><th>Sitenote</th></tr>
<tr><td>Hindernissen</td><td colspan="2">1. Wat zijn volgens u huidige hindernissen om te kunnen innoveren in de GWW?
a. Wat is de reden hier achter?
b. Wat waren momenten dat u dit tegenkwam?
c. Hoe bent u daarmee om gegaan?</td><td>Vaststellen waar de respondent tegenaan loopt als het gaat over innoveren in de bouw.</td><td></td></tr>
<tr><td>Extra onzekerheden</td><td colspan="2">Vanuit de literatuur is gebleken dat er meer onzekerheid is wanneer er een innovatie wordt toegepast dan wanneer er een project met standaardproducten wordt uitgevoerd.
2. Hoe heeft u deze extra onzekerheid ervaren?
a. In het kort, wat is de projectomschrijving?
b. Wat was de innovatie die werd toegepast?
c. Wat was het gevolg van de extra onzekerheid?
d. Hoe had deze onzekerheid invloed op het project?
e. Hoe is er omgegaan met deze extra onzekerheid?</td><td>Bekijken hoe er in de praktijk wordt omgegaan met meer onzekerheid bij het gebruik van innovatie.</td><td></td></tr>
<tr><td colspan="5"><u>Stelling 2: In algemene zin kun je stellen dat onvoorziene gebeurtenissen het gevolg zijn van onzekerheden</u></td></tr>
<tr><td>Onvoorzien gebeurtenis</td><td colspan="2">Introductie tot onvoorziene gebeurtenissen definitie uitleggen, koppeling met extra onzekerheden:
In de projecten waar u bij betrokken was:
3. Welke onvoorziene gebeurtenissen heeft u meegemaakt in het project waar een productinnovatie is toegepast?</td><td>Benoeming van (verschillende) onvoorziene gebeurtenissen die de respondent heeft meegemaakt.</td><td>Onvoorziene gebeurtenissen zijn risico's en kansen die niet zijn geïdentificeerd en resulteren in schade, conflict of het niet halen van project doelen.</td></tr>
<tr><td>Vervolgvragen onvoorziene gebeurtenissen</td><td>Onderwerp</td><td colspan="2">Vragen</td><td>Doel</td></tr>
</table>

Vervolgvragen onvoorziene gebeurtenissen	**Project beschrijving**	4. In het kort, wat is de project omschrijving? 5. Wat was de innovatie die werd toegepast?	Project beschrijving, basis om op door te vragen
	Beschrijving van de gebeurtenis	6. Waar liep u tegen aan in het project wat niet was voorzien?	Beschrijving van de gebeurtenis
	Stelling 3: Wanneer er sprake is van een productinnovatie in een project zou de risicoverdeling tussen partijen anders moeten zijn dan in een project zonder productinnovatie		
	Gevolg van de gebeurtenis	7. Wat was het *gevolg* van de gebeurtenis? a. Was het gevolg acceptabel 8. Wat voor invloed had de gebeurtenis op de uitkomst van het project?	Vaststellen of de gebeurtenis een onacceptabele invloed heeft gehad op de uitkomst van het project, de samenwerking, de financiën of op de planning
	Oplossing van de situatie	9. Wat was de *oplossing* procesmatig gezien? a. Hoe is deze oplossing bereikt? b. Waarom was dit een goede, dan wel niet goede oplossing? c. Wat was het gevolg (rest risico) van de oplossing?	Vaststellen hoe er is gehandeld om dit later te verwerken een advies over de aanpak van onvoorziene gebeurtenissen (correctief)
	Oorzaak van de gebeurtenis	10. Wat was de *oorzaak* van de gebeurtenis? 11. Als u de oorzaak van de gebeurtenis zou categoriseren, welke categorie zou dat zijn? *a. Als men geen categorie weet te noemen, een van deze voostellen:* *1. Politieke risico's* *2. Financiële risico's* *3. Juridische risico's (aanbesteding/contract)* *4. Technische risico's (specificaties/ontwikkeling)* *5. Organisatorische risico's (organisatie van het projectteam)* *6. Geografische risico's* *7. Maatschappelijke risico's*	Vaststellen hoe er is gehandeld om dit later te verwerken een advies over de aanpak van onvoorziene gebeurtenissen (preventief)

Vervolgvragen onvoorziene gebeurtenissen	**Risicodossier**	12. Stond de situatie beschreven in het risicodossier? a. Ja, waarom was beschouwd u het dan toch als onvoorziene gebeurtenis? b. Nee, is het risicodossier erbij gepakt toen de gebeurtenis plaats vond? i. Ja, stond het er helemaal niet in beschreven of stond het er in andere woorden? ii. Nee, waarom niet? 13. Zou ik het risico dossier van u mogen ontvangen?	Vaststellen of de interpretatie van het risicodossier heeft geleid of had kunnen leiden tot de oplossing VRAGEN NAAR RISICO DOSSIER
	Aanbesteding van het project	14. Heeft de manier van aanbesteden invloed gehad op hoe er is omgegaan met de onvoorziene gebeurtenis? *a. Bijv. omdat er meer samenwerking is ontstaan vanuit de aanbesteding.* *b. Bijv. omdat er hele specifieke eisen aan de innovatie zijn gesteld in de uitvraag die niet haalbaar bleken.* 15. Als, volgens u, het project opnieuw zou worden aanbesteed, zou u het dan op een andere manier doen, denkend aan de onvoorziene situatie die is ontstaan? a. Andere procedure? b. Specifiekere eisen, of juist minder specifiek? c. Zo niet, waarom was dit de goede aanbestedingsprocedure?	Vaststellen of er in de praktijk een relatie is tussen de onvoorziene gebeurtenis en de aanbesteding. Vaststellen wat daarbij de factoren zijn die die relatie maken
	Contract	16. Heeft de contractvorm invloed gehad op hoe er is omgegaan met de onvoorziene gebeurtenis? *a. Bijv. omdat er meer samenwerking vereist is gun je elkaar meer* *b. Bijv. minder specifieke risicoverdeling* 17. Als, volgens u, het project opnieuw zou worden uitgevoerd, zou u dan voor andere contractvormkiezen, denkend aan de onvoorziene situatie die is ontstaan? a. Meer of minder samenwerking? b. Meer of minder gezamenlijk risico's dragen? c. Zo niet, waarom was dit de goede contractvorm?	Vaststellen of er in de praktijk een relatie is tussen de onvoorziene gebeurtenis en de contractvorm. Vaststellen wat daarbij de factoren zijn die die relatie maken

Deel 3: Innovatiepartnerschap (8 min)

Stelling 4: Innovatiepartnerschap is een goede toevoeging aan de aanbestedingswet

Indien de geïnterviewde niet bekend is met het innovatie partnerschap, wil ik dezelfde trant vragen stellen over SBIR of Concurrentiegerichte Dialoog.

Onderwerp	Vragen	Doel
Kennis over innovatiepartnerschap	1. Bent u bekend met het innovatiepartnerschap? a. Ja, heb u er ook wel een mee gewerkt? b. Nee, Bent u wel bekend met SBIR (Pre-commercieel inkopen) of concurrentiegerichte dialoog c. Innoveren stimuleert, denkt u dat dat nodig is in de GWW?	Vaststellen in hoeverre de respondent kennis er ervaring heeft met het innovatiepartnerschap *Indien niet bekend met innovatiepartnerschap, de zelfde trant vragen stellen over SBIR of competitieve dialoog.*
Innovatiepartnerschap en onvoorziene gebeurtenissen	We hebben het nu over onvoorziene gebeurtenissen, 2. Denkt u dat het innovatiepartnerschap het omgaan met grote onzekerheden die meekomen met innoveren, beter of slechter faciliteert? a. Waarom beter? b. Waarom slechter?	Bekijken welke relatie de respondent ziet tussen het innovatiepartnerschap en onvoorziene omstandigheden en daarnaast of dit anders is dan bij andere aanbestedingsvormen

Stelling 5: Een innovatie ontwikkelen tijdens een aanbestedingsproces is niet mogelijk omdat innoveren een creatief proces is, dat niet kan worden afgedwongen.

Onderwerp	Vragen	Doel
Aanbesteden en innoveren	3. Bent u van mening dat een productinnovatie in het aanbestedingsproces moet worden uitgevraagd of dat deze moet worden ontwikkeld buiten het project?	Vast stellen of productinnovaties überhaupt wel moeten worden aanbesteed

Deel 4: Afronding (2 min)

Onderwerp	Vragen/opmerking	Doel
Afsluiting		*Samenvatten, afsluiten, eventueel aanbevelingen voor verder onderzoek*

	1. Zijn er onderwerpen niet ter sprake gekomen, die u nog wilt bespreken? 2. Denkt u nog mensen te kennen waarvan u denkt dat het meerwaarde is voor mij om deze persoon te spreken? 3. Heeft u nog vragen voor mij?	Respondent gelegenheid geven om vragen terug te stellen.
	4. Wenst u de uitwerking van het interview en/of de uiteindelijke onderzoeksresultaten te ontvangen? 5. Eventueel: Mag ik contact met u opnemen voor validatie van de onderzoeksresultaten?	Deur openhouden voor validatieronde

B. Unforeseen events

In the interviews, the respondents were asked to elaborate on a situation where an unforeseen event related to innovation occurred. In chapter 7 these situation are described and the important parts are discussed. In this appendix the complete description of each event is added. In addition to chapter 7 here, the type of event, the procurement procedures, the contract form, and variables are indicated. The data in this appendix is in Dutch.

Table B.1: Onvoorziene gebeurtenis 1

Innovatie	Eerste geboorde tunnel in Veengrond
Gebeurtenis	Boor schoof naar achter tijdens het boren omdat er geen goede vijzeldruk was.
Gevolg	Stilstand. Relatief gezien onacceptabel meer dan een ton verlies per dag.
Oplossing	Werd gezamenlijk tussen OG en ON (financieel) opgelost
Type gebeurtenis	Technisch
Aanbesteding	Openbare aanbesteding
Contract	Bouwteam
Toepasbare variabelen	Innovatie uitgevraagd door OG
	Het succes van het project was afhankelijk van de innovatie
	De innovatie was voor meerdere projecten toepasbaar

Table B.2: Onvoorziene gebeurtenis 2

Innovatie	Eerste geboorde tunnel in Veengrond
Gebeurtenis	Boor schoof naar achter tijdens het boren omdat er geen goede vijzeldruk was.
Gevolg	Stilstand. Relatief gezien onacceptabel meer dan een ton verlies per dag.
Oplossing	Werd gezamenlijk tussen OG en ON (financieel) opgelost
Type gebeurtenis	Technisch
Aanbesteding	Openbare aanbesteding
Contract	Bouwteam
Toepasbare variabelen	Innovatie uitgevraagd door OG
	Het succes van het project was afhankelijk van de innovatie
	De innovatie was voor meerdere projecten toepasbaar

Table B.3: Onvoorziene gebeurtenis 3

Innovatie	Betonnen paalwanden in veen/klei grond
Gebeurtenis	Het zoeken naar de juiste uitvoering van betonstorten en bekisting wegtrekken was lastig te vinden
Gevolg	Extra kosten en vertraging. Er was extra beton nodig wat voor vertraging en extra kosten zorgden
Oplossing	Blijven proberen. Risico was voor de aannemer als OG het te risicovol vond mocht traditionele damwanden worden uitgevoerd
Type gebeurtenis	Technisch
Aanbesteding	Gesloten aanbesteding waar gevraagd werd naar alternatieven voor damwanden
Contract	UAV-GC
Toepasbare variabelen	Innovatie uitgevraagd door OG
	Het projectsucces hing niet af van de innovatie
	De innovatie was voor meerdere projecten toepasbaar

Table B.4: Onvoorziene gebeurtenis 4

Innovatie	Geluidswanden bestaande uit zonnepanelen
Gebeurtenis	Geen budget vanuit de klant on het toe te passen in het project
Gevolg	Zijn niet toegepast
Oplossing	Traditionele geluidswanden toegepast
Type gebeurtenis	Financieel
Aanbesteding	Concurrentie gerichte dialoog. Innovatie niet meegenomen in de inschrijving
Contract	PDC (plan, design & construct)
Toepasbare variabelen	Innovatie aangedragen door ON
	Het projectsucces hing niet af van de innovatie
	De innovatie was voor meerdere projecten toepasbaar

Table B.5: Onvoorziene gebeurtenis 5

Innovatie	Verjongingscrème voor asfalt
Gebeurtenis	De weg werd even heel glad na aanbrengen crème
Gevolg	Snelheidsverlaging, extra hinder voor het verkeer
Oplossing	In overleg met OG snelheidsverlaging ingevoerd, geen financiële gevolgen geweest vanwege goede samenwerking
Type gebeurtenis	Technisch
Aanbesteding	Intern ontwikkeld
Contract	DBFM (Design, Built, Finance, Maintenance)
Toepasbare variabelen	Innovatie aangedragen door ON
	Het succes van het project was afhankelijk van de innovatie
	De innovatie was voor meerdere projecten toepasbaar

Table B.6: Onvoorziene gebeurtenis 6

Innovatie	Doorontwikkeling van schade detectiesoftware	
Gebeurtenis	De gemaakt update functioneerde slechter dan eerdere versies	
Gevolg	Tegenvallende oplevering aan klanten	
Oplossing	Veel handmatige correcties. Lange termijn strakker ontwikkelproces, meer stapsgewijs updaten	
Type gebeurtenis	Organisatorisch, technisch	
Aanbesteding	Intern ontwikkeld	
Contract	Losse verkoop aan klanten	
Toepasbare variabelen	Innovatie aangedragen door ON	
	Het succes van het project was afhankelijk van de innovatie	
	De innovatie was voor meerdere projecten toepasbaar	

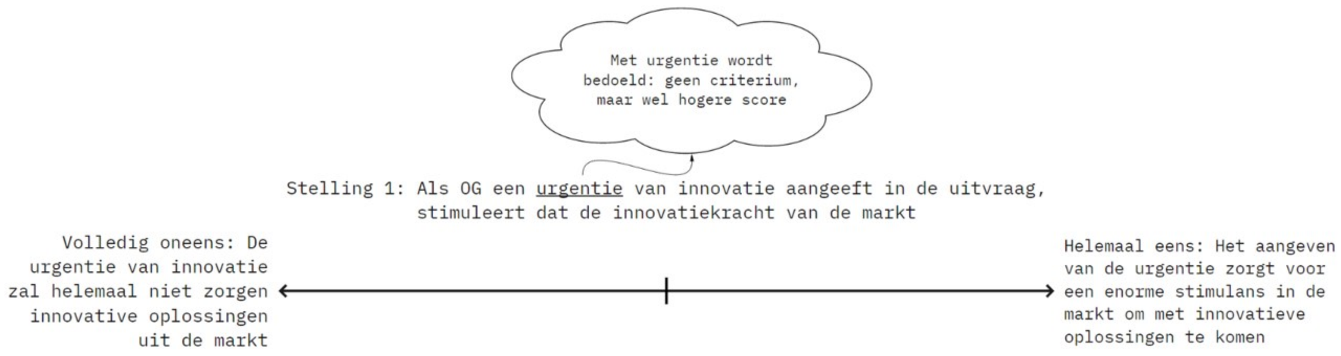
Table B.7: Onvoorziene gebeurtenis 7

Innovatie	Gaten graven in de bodem van de Zee ongeveer 100 meter diep
Gebeurtenis	Het ontwikkelde systeem bleek niet bestad tegen de omstandigheden waarin het moest functioneren
Gevolg	Tijd en budget overschreden
Oplossing	OG heeft werkzaamheden laten overnemen door ander bedrijf, contract niet verleng
Type gebeurtenis	Technisch
Aanbesteding	Onbekend
Contract	Was een buitenladn project, contract onbekend maar risico van uitvoering lag bij ON
Toepasbare variabelen	Innovatie uitgevraagd door OG
	Het succes van het project was afhankelijk van de innovatie
	De innovatie, in de vorm op dat moment, is alleen gebruikt op dat project

C. Validation session handouts

This appendix includes the statements used for the validation of the results described in part III. The experts the statements were discussed in three groups: statements 1&2, statements 3 to 6, and statements 7a to 9. These groups correspond with the three main parts of this research.

Statement 1:



Toelichting:

Statement 2:

Stelling 2: Innoveren in de GWW is alleen mogelijk als de OG het onderdeel maakt van de uitvraag

Volledig oneens: Iedereen kan innoveren, ON heeft daar niet perse de hulp van OG bij nodig

Helemaal mee eens: De enige manier om succesvol productinnovatie in de GWW toe passen is als de OG het uitvraagt

Toelichting:

Statement 3:

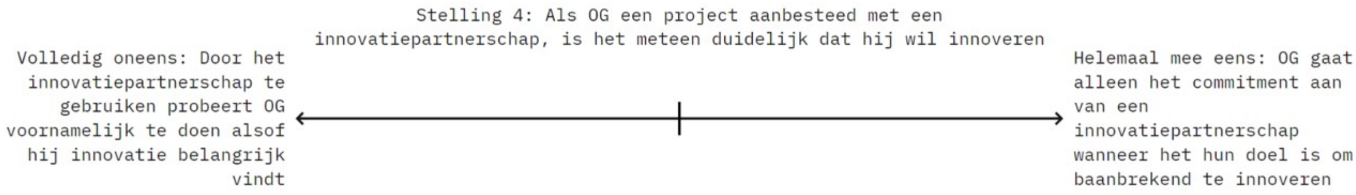
Stelling 3: Omdat het innovatiepartnerschap de ontwikkeling van een innovatie bevat, is het per definitie een lange procedure

Volledig oneens: Innovatiepartnerschap hoeft niet perse een lange procedure te zijn

Helemaal mee eens: Het ontwikkelen van een innovatie duurt lang en als dat onderdeel is van een aanbesteding moet het wel een lang traject zijn

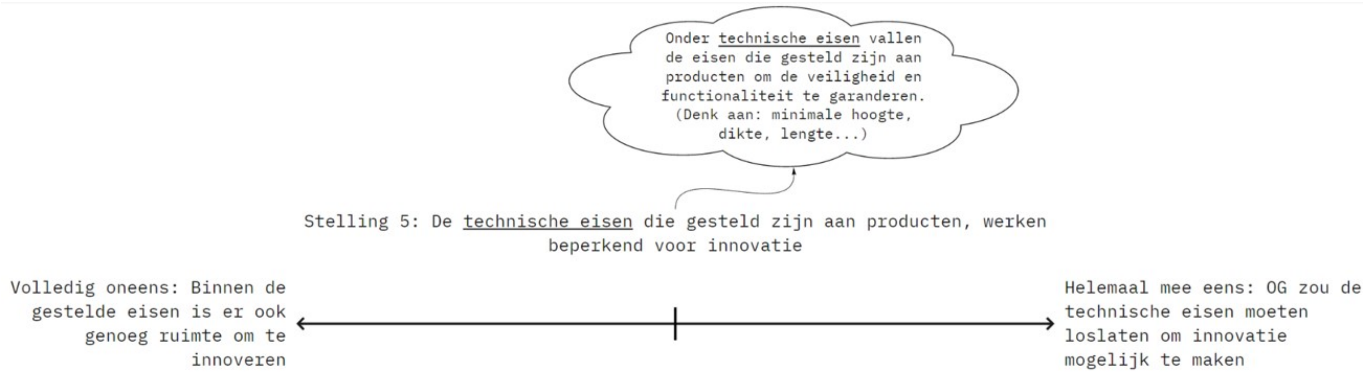
Toelichting:

Statement 4:



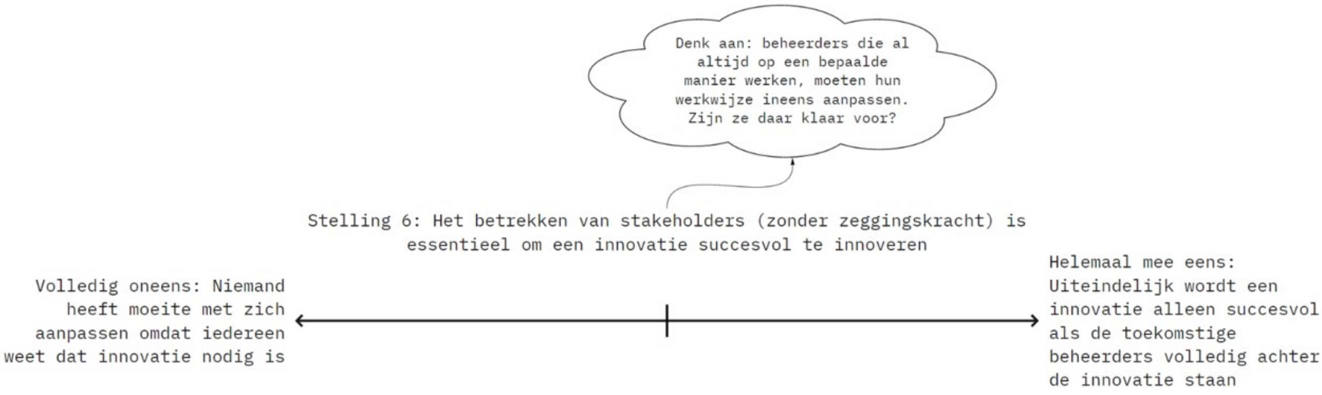
Toelichting:

Statement 5:



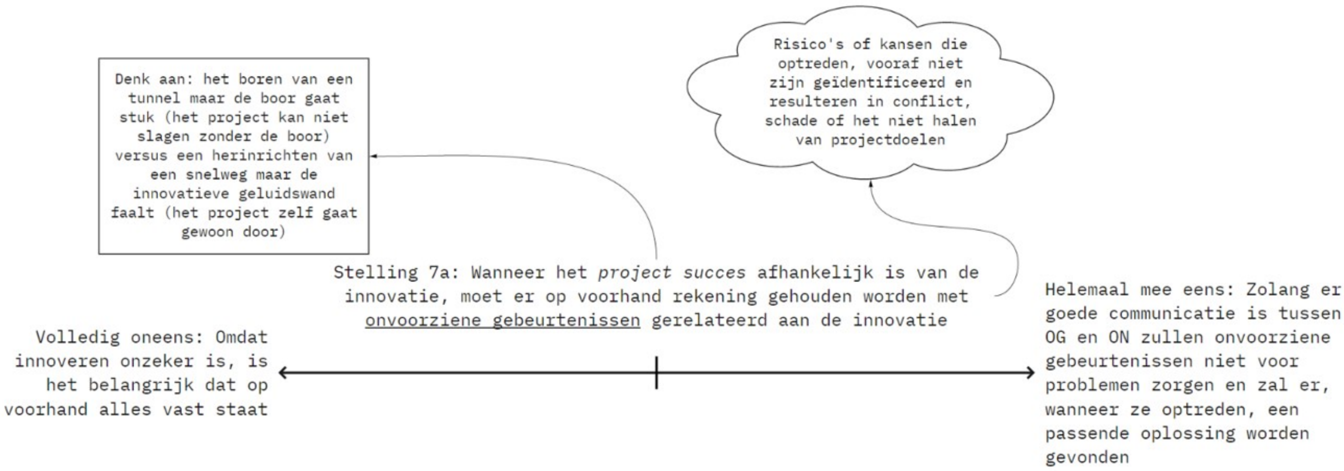
Toelichting:

Statement 6:



Toelichting:

Statement 7a:



Toelichting:

Statement 7b:

Denk aan: Market-pull (innovatie is onderdeel van de uitvraag) versus Technology-push (de innovatie wordt aangedragen door ON)

Risico's of kansen die optreden vooraf niet zijn geïdentificeerd en resulteren in conflict, schade of het niet halen van projectdoelen

Stelling 7b: Wanneer de innovatie is *uitgevraagd door OG*, moet er op voorhand worden bepaald hoe er wordt omgegaan met <u>onvoorziene gebeurtenissen</u> gerelateerd aan de innovatie

Volledig oneens: Omdat innoveren onzeker is het belangrijk dat op voorhand alles vast staat

Helemaal mee eens: Zolang er goede communicatie is tussen OG en ON zullen onvoorziene gebeurtenissen niet voor problemen zorgen en zal er, wanneer ze optreden een passende oplossing worden gevonden

Toelichting:

Statement 8:

Stelling 8: Er bestaat een verschil tussen de risicoverdeling voor het hele project en risico's gerelateerd aan de innovatie

Volledig oneens: De innovatie is onderdeel van het project dus er moet geen onderscheid zijn tussen de risicoverdeling

Helemaal mee eens: Omdat innovatie maar een onderdeel is van het project moet men niet vergeten dat de rest van het project niet nieuw is

Toelichting:

Statement 9:

Stelling 9: Het detail niveau van de UAV-GC, op het gebied van risicoverdeling, is te beperkend om te innoveren

Volledig oneens: Wanneer de volledige ruimte van de UAV-GC wordt benut is er veel mogelijkheid om te innoveren

Helemaal mee eens: Wanneer er wordt geïnnoveerd is het belangrijk dat de risicoverdeling niet volledig gedetailleerd is om de onzekerheid van innoveren op te kunnen vangen.

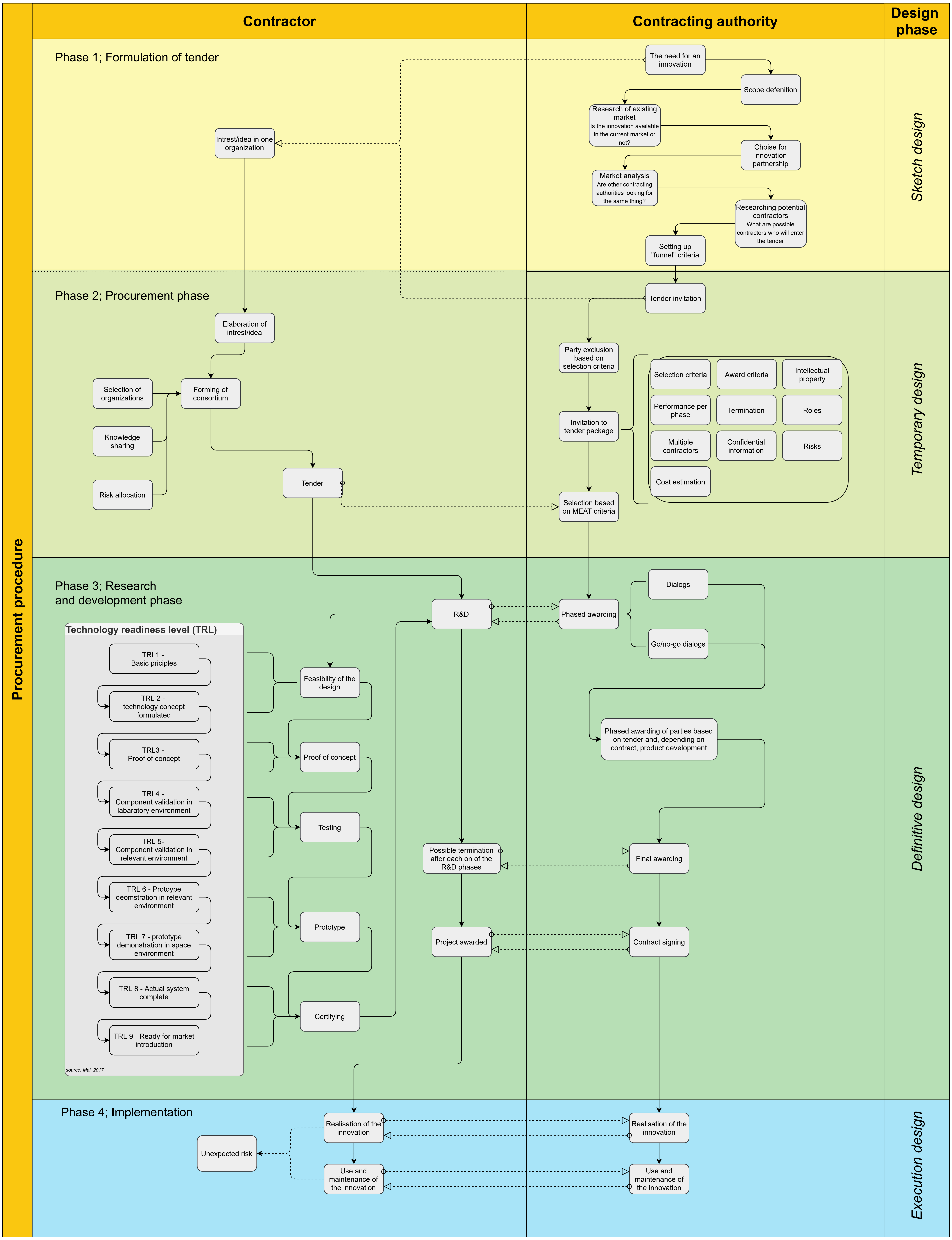
(eventueel) Beter passende contractvorm:

Toelichting:

D. The Innovation Partnership

In chapter 3, the Innovation Partnership procedure is explained. Figure 3.2 gives an overview of the content of the procedure, this overview is based on a full scheme that is added in this appendix. A full visualization of the procedure can be found, in the digital version of report, on the next page. Due to its size, it is not possible to include (a readable version of) the figure in the printed document.

For digital version the Innovation Partnership procedure is added in A2 size at the back of the document



Procurement procedure
Contractor
Contracting authority
Design phase
Phase 1; Formulation of tender
The need for an innovation
Scope defenition
Research of existing market
Is the innovation available in the current market or not?
Intrest/idea in one organization
Choise for innovation partnership
Market analysis
Are other contracting authorities looking for the same thing?
Researching potential contractors
What are possible contractors who will enter the tender
Setting up "funnel" criteria
Sketch design
Phase 2; Procurement phase
Tender invitation
Elaboration of intrest/idea
Party exclusion based on selection criteria
Selection of organizations
Forming of consortium
Selection criteria
Award criteria
Intellectual property
Invitation to tender package
Performance per phase
Termination
Roles
Knowledge sharing
Multiple contractors
Confidential information
Risks
Tender
Cost estimation
Risk allocation
Selection based on MEAT criteria
Temporary design
Phase 3; Research and development phase
Dialogs
R&D
Phased awarding
Technology readiness level (TRL)
Go/no-go dialogs
TRL1 - Basic priciples
Feasibility of the design
TRL 2 - technology concept formulated
Phased awarding of parties based on tender and, depending on contract, product development
TRL3 - Proof of concept
Proof of concept
TRL4 - Component validation in labaratory environment
Testing
TRL 5- Component validation in relevant environment
Possible termination after each on of the R&D phases
Final awarding
TRL 6 - Protoype deomstration in relevant environment
Prototype
TRL 7 - prototype demonstration in space environment
Project awarded
Contract signing
TRL 8 - Actual system complete
Certifying
TRL 9 - Ready for market introduction
source: Mai, 2017
Definitive design
Phase 4; Implementation
Realisation of the innovation
Realisation of the innovation
Unexpected risk
Use and maintenance of the innovation
Use and maintenance of the innovation
Execution design