Thesis Report

ORCHESTRATE OR IMPROVISE
How to Conduct Interdisciplinary Collaboration in a DBFMO Design Competition?

CME2001 MSc Construction Management & Engineering - Graduation Thesis
Joost van de Ven, 1353411

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TU Delft
ARUP
“The context of the construction industry is changing dramatically; there is a new call for transparency and an increased need for cooperation, a changing role of the client and an increasing demand for a service instead of a product.”

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Preface

The document before you is the Graduation Thesis report for the master study Construction Management Engineering in the Faculty of Civil Engineering and Geosciences at Delft University of Technology. This thesis provides with the results of a research into interdisciplinary collaboration in Dutch public tender DBFMO design competition. It aims to give an understanding in this particular topic from an aggregation of theoretical context (literature study) and practice (case study).

The ‘case study’ is chosen as the main research method for researching interdisciplinary collaboration in a DBFMO design competition. The choice for the Hoge Raad der Nederlanden is driven by a personal interest in knowing how the collaboration between a number of leading Dutch building construction parties eventuated. The Hoge Raad project's design involved a plurality of (complex) requirements relating to all life-cycle phases of the DBFMO.

As this thesis brings forward, interdisciplinary collaboration in itself is a complex phenomenon that has not yet been contemplated in its full width in academic research. This thesis intends to contribute to wider understanding, by showing the different observables for interdisciplinary collaboration in DBFMO design competitions in line. Withal, the project of the Hoge Raad der Nederlanden is a contemporary case study par excellence. This project, currently in its construction phase, is the first example of complete BIM implementation in a DBFMO after a competition win. It demonstrates the showcase of a consortium that had initially organised design output during the competition phase and is suddenly faced with formal structured frameworks imposed by government legislation.

My interest in DBFMO collaboration, which developed after researching the (BIM) collaboration in the technical design phase of Hoge Raad during another course in the CME study program, has driven me to dedicate my graduate research to this topic.

Simultaneously studying MSc Architectural Engineering at the faculty of Architecture, I aspire to expand the research I have done for this thesis to the graduation research in Architectural Engineering, and further elaborate upon it.

My aim is to develop design tools, which can be utilised by architects to face spatial, functional, social design and technical possibilities and developments that are brought about with collaboration in DBFMOs. The goal is to gain a full contemplation of collaboration in DBFMOs from a construction management as well as an architectural viewpoint.

Amsterdam, 12 April 2015

Joost van de Ven
Executive Summary

Introduction
In new integrated contracts such as the DBFMO, the Rijkswaagoedbedrijf (Dutch Government Building Agency) tries to publicly tender the full life-cycle responsibility of the Design, Build, Finance, Maintenance & Operate to a single party. In order to convey all terms of the DBFMO contract, an initiating subscriber looks for other disciplines (e.g. architects, engineering firm, facility management etc.) to form consortiums, and to subscribe to DBFMO tender competitions. Although working in the same industry, disciplines such as architects, engineers, contractors come up with very different backgrounds and ways-of-working.

This research contributes to the management sciences of interdisciplinary collaboration in integrated building construction projects. Its objectives are to understand (in theory and practice) the complexity of interdisciplinary collaboration in public tender DBFMO design competitions, and from this to induce roles and instruments to optimise collaboration, which is reflected on by practice. The research furthermore elaborates on complexity by drawing parallels with other phenomena described in process and collaboration literature. These parallels provide an interesting perspective on how interdisciplinary collaboration in practice manifests. The research was conducted at Arup Amsterdam. For the case study, and later evaluation of the improvement proposal, consortium partners of the case project Hoge Raad der Nederlanden were interviewed. Interviews with consortium partners provided with a comprehensive view of different disciplines on the interdisciplinary collaboration process.

The research was conducted at Arup. Arup in the Netherlands is a team of consultants, engineers and designers, holding office in Amsterdam. The office has build an extensive portfolio, including the Public Library Amsterdam (OBA), the Rijksmuseum, the Nesciobridge and the Ministry of Finance. An integrated approach results in an efficient process and a successful product. Arup combines social relevance with creativity and a global network of the best knowledge and practices. For large and small projects, Arup always looks at the bigger picture, applying global knowledge and global experience locally. Arup tries to look from the perspective of other parties it collaborates with. Therefore, the alignment question is one that in particular pertains to Arup.

This thesis research is performed for the Master program Construction Management Engineering and is supported by the department of Design and Construction Processes within the faculty of Civil Engineering and Geosciences and the department of Real Estate & Housing within the faculty of Architecture. CME puts a strong effort in educating its student in the needs and challenges of today’s construction industry, and demands for the students to critically look upon this. The education comprises a wide variety of courses, given at the different faculties and addresses different topics, e.g. project and process management, risk management, PPP, financial engineering, infrastructure design. The department of Design and Construction Processes, within the faculty of Civil Engineering and Geosciences, chair the education programme.

Literature
A literature study was conducted constructively, to expound the theoretical context of interdisciplinary collaboration in a DBFMO design competition. Literature first shows how in contemporary building construction market there is a communal effort of parties to gain control over design issues and how this necessitates a more systematic approach. In the current practice, team processes are hampered because knowledge between disciplines is insufficiently shared, and project managers often seem unaware of this. Moreover, a breakdown in collaboration and a lack of clarity in describing roles induces conflict between disciplines. A sequential and fragmented design, adversial business contexts and insufficient time structuring can be designated as hinder for team processes. Lastly, the client’s output specification for the competition constrains interdisciplinary collaboration, and the contractual division between the consortium companies due to competition outline does not bring holistic responsibility.

Methodology
The research can be seen as descriptive, explanatory and exploratory. Inputs for these types of researches are distinct, as it uses diverse types of evidence: documents, observations and interviews. In this thesis methodological triangulation is used, to find different aspects of the research subject from different types of evidence. A case study is selected as main method and suits the needs for this research. It is chosen to use a single case study, to deliver specific optimisation for this project, and for other projects to learn from. By means of descriptive research, interview minutes were transformed into a case report, which provided an overview of all respondents within one case.
Interviews form the core activity for the research investigator in this case study research. By using results of the case study, explanations for complexities in interdisciplinary collaboration in DBFMO design competitions are found with the help of explanation building. Using the findings from theory (literature study) and practice (case study), conclusions are drawn on perceived phenomena. The assertion of phenomena is supported by academic literature: an explanation to observed customs is given, from an understanding of other processes in the construction sector. On basis of an understanding of the described phenomena, a suggested method to improve collaboration framework is described. Roles and instruments (directives, process tree, meetings, strategies etc.) are altered to overcome a number of hindrances. Using practical directions given by interviews from Hoge Raad, and mirroring these to the complexities described in Chapter C, roles and instruments for improvement are induced. By means of an open-ended interview during which results of the case study are presented to the Hoge Raad participants, the suggested roles and instruments for improvement were internally communicated.

Results

Positions in Interdisciplinary Collaboration

The theoretical context directs at disciplinary interests that have to be merged to control design risks in interdisciplinary collaboration. Moreover, insufficient knowledge sharing hampers team processes and can be attributed to a sequential and fragmented design, which can be explained by:

1. Different types of businesses that are brought together in the consortium; disciplines hold a different stake.
2. Disciplines hold their stakes on different levels of detail during the design competition.

Different interests appear at the constitution of the design teams, that after competition win will be contracted as the different consortium companies i.e. Engineering Procurement & Construction (EPC – covering the Design & Build) and Measured Term Contract (MTC- covering the Maintenance & Operation): conflicts between different disciplines arise due to a breakdown in cooperation and a lack of clarity in describing roles and responsibilities. The case study shows that complexity in controlling design risks manifests as both D&B and M&O parties are not used to linking of M&O aspects to a design project. Complexity in disciplinary knowledge sharing embodies as requirements from follow-up phases bring risk of design issues that cannot be located with a single discipline or DBFMO term. This complexity can be explained by sectional interest: the contractual constructs fence off an overall responsibility for the design. Therefore, disciplinary knowledge sharing is needed; a shared understanding can deliver creative coupling. A shift of management roles is introduced, that serves the purpose of letting disciplines discuss based on levels in value chain instead of consortium companies. These roles serve respectively the purpose of:

1. Custodian: project content (position)
2. IC manager: collaboration process (relation)
3. Coordination manager: coordination of competition (margins)

In the implementation of instruments in practice, the choice of the right people for the right places in interdisciplinary collaboration is crucial. For the role of the interdisciplinary collaboration manager, a consortium looks for a person who is objective, knowledgeable and authoritative. In the practical execution of the instruments to optimise interdisciplinary collaboration this can be a challenge.

Relations in Interdisciplinary Collaboration

The theoretical context presents an urge of parties to understand the different levels of control for the DBFMO design process, but the current organisational structures result in fragmented interests and non-collaborative working. The organisation of a DBFMO consortium struggles with client satisfaction and process management, due to insufficient knowledge on integration and focus on interfaces between different disciplines and award criteria. Practice shows that a difference in organisational approach of parties makes relations in interdisciplinary collaboration more complex: Top-down decisions (strategic flows) were insufficiently controlled by a scope of work that can be controlled. Design issues need to be prioritised. In the case study, prioritisation is done by hierarchy and power-play of disciplines. Moreover, collaboration inefficiencies remain to exist because of structuring the meetings:

1. Design choices based on power-play were stipulated on a high level and the consecutive strategic flows are were insufficiently controlled by a scope of work for the work floor level.
2. The meetings need to be categorised per subject instead of separating parties

Approaches to project activities lead to design decisions made on different levels: design activities can best develop in a sequential process (hierarchy); other activities demand for researching in a network. Collaboration in a DBFMO consortium
can be seen as working in a hybrid organisation: a sequential (hierarchical) process forms the basis, from which can be deviated, for disciplines to start working in a network. In order to optimise the relations in interdisciplinary collaboration, the issue of network vs hierarchy is devised by creating involvement in actively monitoring organisational levels, interfaces and discipline-crossing activities:

- Meetings are organised around the different levels in the value chain in order to create a multilevel discussion. These meetings serve respectively the purpose of:
  1. Project content (positions)
  2. Collaboration process (relations)
  3. Coordination of competition (margins)
- Custodians per strategic flow create workscopes: these convey domains in which work packages are carried out.
- The workscopes give room for the discipline to explore different solutions for solving work packages in relation to: other work packages and workscopes in the project, other projects or other activities within the party’s own network.

Regarding the relations in interdisciplinary collaboration, the new role distinction that divides between process and content should be made explicit to all disciplines. The ‘shadow of the traditional process’ is prevented if managers keep the focus on the process. Taking the lead is actively imposed on the MTC, by means of establishing the MTC directives. This gives them a small step ahead in the design process, in order to have their wishes safeguarded.

**Margins for Interdisciplinary Collaboration**

The theoretical context exhibits a disparity between competition and collaboration:

- The client’s output specification constrains interdisciplinary collaboration: a basic and functional design demand (positive effect), and a narrowly defined service-output specification (negative) oppose each other.
- Contractual division between the EPC and MTC due to competition outline does not bring holistic responsibility.

In the practice of the *Hoge Raad* project, the consortium struggled with controlling this disparity:

- A changing client demand and rebate mechanism are insufficiently interpreted and can be explained by parties not being used to a service-led contract.
- Different accounting systems for the expenses leads to ignorance between EPC and MTC in understanding each other’s demands/supplies.

Interdisciplinary collaboration is externally pressurised by margins set out by the client and by the consortium itself. The increased outsourcing of activities by the client in a service-led contract that is awarded in a strictly regulated competition leads to imbalance in effective dialogue and keeping information in the consortium.

In order to optimise handling the margins of interdisciplinary collaboration, the issue of being caught between collaboration and competition is relieved by means of making explicit the set-up for multilevel negotiation, it is purposed that efficient interdisciplinary collaboration can lead to a reduction of the transaction costs, lowering risk aversion and stimulating information sharing. MTC directives for better including M&O requirements furthermore helps to demarcate the focal points. Regarding the margins of interdisciplinary collaboration, interfaces need to be mapped to make work scopes usable for cost determination. By mapping out all interfaces in work scopes, and having set out the basis for all meetings, disciplines will be better informed about the delivery times. These delivery times are dependent on negotiated work package durations. Interfaces and overlay will still be apparent, but by making the work scopes explicit, it is better foreseeable.

**Limitations**

Main limitations of the research can be described as the following:

- The literature research revealed a limited choice of literature. It could thus be argued that using the variables from literature study does not fulfill the requirement of construct validity.
- In the case study, despite the fact that the investigator of this research tried to conduct a truthful representation of the daily practice, generalisability and utility of findings can result by subjective interpretation.
- Interviews have produced an internal validation of the above-mentioned arbitrary decisions, and made a contemplation of linkages of analyses (internal validity, reliability) possible. However, these do not go into detail and cannot one-on-one be extrapolated to other projects (external validity)

Moreover, there are three methodological limitations:

- The limitation of a single-case research is that the interview sample size is limited. Only a relative small number of participants could be questioned. Due to this small sample size, it is arguable if results can be generalised.
- The method used for collection of data may have been biased. This might be due to the theoretical preparation for the interview.
- In addition to the methodological limitation, there are also longitudinal effects. The time available to investigate this research problem is constraint by due dates and interviewees' availability.
- This thesis research does not provide external validity that research results can be extrapolated to other DBFMO design competitions.

**Recommendations for Arup**

1. **Formalise the envisioned position of Arup as engineer in DBFMO competitions**
   Arup is a multidisciplinary design organisation involved in copious interdisciplinary design projects. As Hoge Raad showed, it is important that disciplines nail the colours to the mast: by addressing their foremost characteristics, others will discover interfaces and will actively search for collaboration.

2. **Practice the use of the proposal for optimised collaboration by means of internal workshops**
   DBFMO demands for the understanding of different paradigms of the disciplines involved. This is something that can be best learned from practice. Sharing practical knowledge, and utilising the different disciplinary knowledge within Arup, could make it possible to simulate interdisciplinary collaboration in workshops.

3. **Use the schemes for an optimised collaboration for discussion meetings for the establishment of consortiums**
   The outlined scheme can be used as in consortium establishment, to quickly inform other disciplines about Arup’s methodology for consortium collaboration.

4. **Stimulate further research on interdisciplinary collaboration in general**
   Interdisciplinary collaboration, deserves more attention, with the emerging of integrated contracts.

**Recommendations for Further Research**

1. **Content of Work Packages and Output**
   In this research, interdisciplinary collaboration is not researched on level of content of work packages. The goal of work packages is to deliver output that can be used for cost administration. From this thesis research, the improvement proposal can be used to frame work packages, and on basis of practical insights and knowledge of cost administration, work packages can be compounded.

2. **Client position in DBFMO competitions**
   In this research, interdisciplinary collaboration is looked at on the level of process; however, it would be worthwhile to look at the interpretation of output specifications, award criteria and dialogues, by individual disciplines.

3. **Consortium contract structures in DBFMO competitions**
   Different possibilities of change of consortium contract structures could be argued to endow interdisciplinary collaboration, from different perspectives, e.g:
   - The perspective of EPC
   - Alliancing (client involvement)
   - Moving interfaces to either EPC or MTC

4. **Usage of BIM in DBFMO (design competitions)**
   The Hoge Raad as the first top-down obligated implementation of BIM in a DBFMO after competition win in the Netherlands has brought many issues regarding interdisciplinary collaboration to the table. In this light, ‘BIM usage in DBFMO (design competitions)’ provide basis for an extensive research.

5. **Traditional phasing in the light of DBFMO**
   As this thesis research shows, traditional phasing in DBFMO competitions becomes of less importance due to the competition’s time structuring. Terms, such as ‘preliminary design+’ or ‘++’ are named to designate the demanded detail for documents. However, a new scale of detail needs to be defined.
Samenvatting

Introductie

In nieuwe geïntegreerde contracten, zoals de DBFMO, probeert het Rijkswegbedrijf (voorheen: Rijkswegdienst) de hele verantwoordelijkheid voor het ontwerpen (Design), bouwen (Build), financieren (Finance), onderhouden (Maintenance) en service verlenen (Operate) publiek aan te bieden aan een enkele partij. Om al deze onderdelen van het DBFMO contract te kunnen ondervangen, zoekt de inschrijver voor andere disciplines (bijv. architect, ingenieur, facility management) om een consortium te vormen, om deel te nemen aan DBFMO competities. Hoewel men in dezelfde industrie werkt, zijn verschillende achtergronden en manieren van werken.

Dit onderzoek draagt bij aan de managementwetenschappen naar interdisciplinaire samenwerking naar geïntegreerde bouwprojecten. Het onderzoeksdoel is om te begrijpen (vanuit theorie en praktijk) wat de complexiteit van interdisciplinaire samenwerking in publiek aanbestede DBFMO ontwerpcompetities is, om van daaruit rollen en instrumenten te introduceren die samenwerking kunnen verbeteren. Deze is daarna geëvalueerd door de praktijk. Het onderzoek gaat verder in op complexiteit door vergelijkingen te maken met fenomenen beschreven in proces- en samenwerkingsliteratuur. Deze parallellen bieden een interessant perspectief op hoe interdisciplinaire samenwerking in de praktijk vorm krijgt. Dit onderzoek is uitgevoerd bij Arup Amsterdam. Voor de case study en de latere evaluatie van het verbetervoorspel, zijn consortium partners uit het case study project Hoge Raad der Nederlanden geïnterviewd. Interviews boden een omvangrijke kijk op hoe verschillende disciplines in het interdisciplinaire samenwerkingsproces staan.

Het onderzoek is uitgevoerd bij Arup. Arup in Nederland is een team van consultants, ingenieurs en ondernemers, die kantoor houdt in Amsterdam. Het kantoor heeft een uitgebreide portfolio, waaronder de Openbare Bibliotheek Amsterdam (OBA), het Rijksmuseum, de Nescio brug en het Ministerie van Financiën. Een geïntegreerde aanpak resulteert in een efficiënt proces en een succesvol product. Arup combineert maatschappelijke relevantie met creativiteit en een wereldwijd netwerk van de beste kennis en praktijken voor grote en kleine projecten. Arup kijkt altijd naar het grotere plaatje, het toepassen van wereldwijde kennis en wereldwijde ervaring lokaal. Arup probeert te kijken vanuit het perspectief van andere partijen waarmee zij samenwerkt. Daarom is het vraagstuk over uitlegging van disciplines van toepassing op Arup.

Dit thesis-onderzoek is uitgevoerd voor de masteropleiding Construction Management & Engineering, dat wordt ondersteund door de afdeling Bouwprocessen binnen de faculteit Civiele Techniek en Geowetenschappen en de afdeling Real Estate & Housing van de faculteit Bouwkunde. CME legt een sterke nadruk in de educatie van haar studenten op de behoeften en uitdagingen van de huidige bouwsector, en eist van haar studenten om kritisch te kijken op dit. De opleiding bestaat uit een breed scala aan vakken, gegeven op de verschillende faculteiten en behandelt verschillende onderwerpen, zoals project- en procesmanagement, risicomanagement, PPP, financial engineering en ontwerp van infrastructuur. De afdeling Bouwprocessen binnen de faculteit Civiele Techniek en Geowetenschappen, is penvoordezer van de opleiding.

Literatuur

Een literatuurstudie is voor onderbouwing gebruikt, om de theoretische context van interdisciplinaire samenwerking uiteen te zetten in een DBFMO-ontwerpwedstrijd. Literatuur toont hoe in de hedendaagse bouwsector er een gemeenschappelijke behoefte van partijen is om controle over ontwerpkwesties te krijgen en toont een zoektocht naar een systematische aanpak. In de huidige praktijk worden teamprocessen belemmerd omdat kennis tussen disciplines onvoldoende gedeeld wordt; projectmanagers lijken vaak niet op de hoogte te zijn van dit. Een breuk in de samenwerking en een gebrek aan duidelijkheid in de beschrijving van de rollen, induceren conflicten tussen disciplines. Een sequentiële en geïntegreerde aanpak ontwerp, ongunstige zakelijke contexten en onvoldoende planning kan worden aangewezen als een obstakel voor teamprocessen. Een literatuurstudie is voor onderbouwing gebruikt, een systematische aanpak behoefte en ontwerp van infrastructuur. De afdeling Bouwprocessen binnen de faculteit Civiele Techniek en Geowetenschappen, is penvoordezer van de opleiding.

Methodologie

Dit onderzoek kan worden gezien als beschrijvend, verklarend en oriënterend. De verschillende inputs voor dit onderzoek onderscheiden zich, omdat er gebruik is gemaakt van een drietal bewijsmiddelen: documenten, observaties en interviews. Deze thesis, methodological triangulation, is geschreven.
met het doel om het onderwerp vanuit diverse perspectieven te analyseren gebaseerd op onderscheidend bewijsmateriaal.

Een casus-studie vormt het fundament van de thesis en past bij de behoefte van dit onderzoek. De keuze voor een enkele casus zorgt ervoor dat de onderzoeksresultaten bijdragen aan de optimalisatie van het betreffende project. Tevens kan het onderzoek gebruikt worden als inspiratiebron voor andere projecten. Beschrijvend onderzoek is toegepast, waarbij interview notulen zijn omgezet naar een casus rapport; een overzicht van alle respondenten.

Interviews vormen de kernactiviteit in deze casus studie. Door het analyseren van de resultaten uit de case study zijn er verklaringen gevonden voor de complexiteit in interdisciplinaire samenwerking in de DBFMO-design competities met explanation building. De bevindingen zijn gebaseerd op zowel theoretische informatie (literatuuronderzoek) en praktische informatie (casus-studie). De beweringen in deze thesis worden ondersteund door wetenschappelijke literatuur: een verklaring voor de waargenomen gewoonten wordt gegeven, waarbij andere processen in de bouwsector in overweging worden genomen. Op basis van de inzichten betreffende de beschreven verskijnselen, wordt een werkwijze voorgesteld met het doel om het samenwerkingsveld te verbeteren. Rollen en instrumenten (richtlijnen, proces boom, vergaderingen, strategieën, etc.) zijn gewijzigd om een aantal hindernissen te overwinnen. Praktische aanwijzingen uit interviews met de Hoge Raad worden toegepast om de in hoofdstuk C beschreven complexiteit te bestuderen en rollen en instrumenten voor verbetering te introduceren.

Resultaten
Posities in interdisciplinaire samenwerking

De theoretische context van deze thesis richt zich op het samenvoegen van disciplinaire belangen en de controle van design risico’s bij interdisciplinaire samenwerking. Het onvoldoende delen van kennis kan leiden tot een belemmerd team process en een sequentieel en gefragmenteerd ontwerp. Dit fenomeen kan verklaard worden door:
1. Verschillende soorten bedrijven worden samengebracht in een consortium; bedrijven hebben verschillende beweegredenen.
2. Vakgebieden focussen op verschillende niveau’s van details tijdens de ontwerpcompetitie.

Verschillende belangen verschijnen bij de formatie van de ontwerp teams, die bij winst van een ontwerp competitie zullen worden gecontracteerd als de verschillende consortium bedrijven, o.a.: Engineering Procurement & Construction (EPC – verantwoordelijk voor de bouw- en design activiteiten) en Measured Term Contract (MTC-verantwoordelijk voor de onderhoud en operatieve aspecten). Conflict tussen verschillende disciplines ontstaan als gevolg van een breuk in de samenwerking en een gebrek aan duidelijkheid in de beschrijving van rollen en verantwoordelijkheden. De casus-studie toont aan dat de complexiteit bij het beheren van design risico’s wordt vergroot doordat zowel D & B en M & O partijen niet gewend zijn om M&O aspecten toe te passen op het design project. Complexiteit in disciplinaire kennisdeling krijgt vorm zodra eisen van vervolgfases risico’s brengen, omdat ontwerp problemen niet kunnen worden ondergebracht bij een enkele discipline of DBFMO contractonderdeel. Deze complexiteit kan worden verklaard door een sectioneel belang: door het gebruik van contractuele contracten kunnen design verantwoordelijkheden worden afgeschoven. Disciplinaire kennisuitwisseling is daarom van uiterst belang en kan leiden tot een gedeeld begrip en creative coupling. Een verschuiving van managementfuncties wordt geïntroduceerd, waarbij de verschillende disciplines onderhandelen op basis van hun plaats binnen de value chain (waardeketen) in plaats van de consortium.

1. Custodian: projectinhoud (positie)
2. IC manager: samenwerkingsprocess (relatie)
3. Coordination manager: coördinatie van de competitie (marges)

Bij de uitvoering van de instrumenten in de praktijk is de keuze van de juiste mensen op de juiste plaatsen in interdisciplinaire samenwerking cruciaal. Voor de rol van Interdisciplinary Collaboration manager zoekt men een persoon die objectief, deskundig en gezaghebbend is. In de praktische uitvoering van de instrumenten om de interdisciplinaire samenwerking te optimaliseren kan dit een uitdaging zijn.

Relaties in interdisciplinaire samenwerking

Het theoretische kader presenteert een drang van partijen om de verschillende niveaus van controle voor het DBFMO-ontwerp proces te begrijpen, maar de huidige organisatiestructuren resulteren in gefragmenteerde belangen en niet-collabotatiieve houdingen. De organisatie van een DBFMO-consortium worstelt met klanttevredenheid en procesmanagement, vanwege onvoldoende kennis over integratie en focus op de interfaces tussen verschillende disciplines en gunningscriteria. Praktijk toont aan dat een verschil in de organisatorische aanpak van de partijen de relaties in interdisciplinaire samenwerking complexer maakt: Top-down beslissingen (gestrategische stromen) waren onvoldoende.
gecontroleerd door een workflow van de werkzaamheden die kunnen worden gemonitord. Ontwerp kwesties moeten worden geprioriteerd. In de case study, werd prioritering gedaan door hiërarchie en power-play van disciplines. Bovendien blijven in de samenwerking in efficiënties bestaan door de structuur van vergaderingen:

1. Ontwerkteuzes op basis van power-play zijn bedoeld op een hoog niveau en de opeenvolgende strategic flows werden onvoldoende gecontroleerd door een workflow van de werkzaamheden voor de werkvloer niveau.
2. De vergaderingen moeten per onderwerp worden geëxposeerd en in plaats van het scheiden van partijen

Verschillen in benaderingswijzen van ontwerpactiviteiten leiden tot beslissingen die op verschillende niveaus te ontwerpen: het ontwerpactiviteiten het beste kan ontwikkelen in een sequentieel proces (hiërarchie); andere activiteiten vraag onderzoeken in een netwerk.Samenwerking in een DBFMO consortium kan worden gezien als werken in een hybride organisatie: een sequentiële (hiërarchisch) proces vormt de basis, van waaruit kan worden afgeweken voor disciplines die werken in een netwerk. Om de verhoudingen in interdisciplinaire samenwerking te optimaliseren, is de kwestie van het netwerk vs hiërarchie het hoofd geboden door het creëren van betrokkenheid bij het actief volgen van organisatorische niveaus, interfaces en discipline-crossing activiteiten:

- De vergaderingen worden georganiseerd rond de verschillende niveaus in de waarden van een multilevel discussie te creëren. Deze bijeenkomsten dienen respectievelijk het doel van:
  1. project inhoud (positie)
  2. samenwerking proces (relatie)
  3. coördinatie van de mededeling (marges)
- Custodians per strategic flow creëren work scopes: deze over te brengen domeinen waarin werkpakketten worden uitgevoerd.
- Work scopes geven ruimte voor de discipline om verschillende oplossingen te verkrijgen voor het oplossen van werkpakketten in relatie tot: andere werkpakketten en workscopes in het project, andere projecten of andere activiteiten binnen het eigen netwerk van de partij.

Ten aanzien van de relaties in interdisciplinaire samenwerking, moeten de nieuwe rollen, die onderscheid maken tussen proces en inhoud expliciet worden gemaakt voor alle disciplines. De 'schaduw van het traditionele proces' wordt voorkomen als managers focus houden op het proces. De MTC moet actief het voortouw nemen, door middel van MTC-richtlijnen. Dit geeft hen een kleine stap vooruit in het ontwerpproces, met het oog op hun wensen te waarborgen.

Margins van interdisciplinaire samenwerking

De theoretische context vertoont een discrepantie tussen competitie en samenwerking:

- De output specifiek van de cliënt beïnvloedt interdisciplinaire samenwerking: een eenvoudig en functioneel ontwerp van de vraag (positief effect), en een nauw omschreven dienst-uitgang specificatie (negatief) tegenover elkaar.
- Contractuele scheiding tussen de EPC en MTC als gevolg van competitie omlijning brengt geen holistisch verantwoordelijkheidsgevoel.

In de praktijk van de Hoge Raad worstelde het consortium met het beheersen van deze ongelijkheid:

- Een veranderende vraag van de client en het kortingsmechanisme werden onvoldoende geïnterpreteerd, omdat partijen gewend zijn aan een service-gedreven contract.
- Verschillende boekhoudsystemen voor de uitgaven leidt tot onwetendheid tussen EPC en MTC in het begrijpen van elkaars wensen / benodigdheden.

Interdisciplinaire samenwerking wordt extern onder druk gezet door de marges die de opdrachtgever te stellen en door het consortium zelf. De toegenomen uitbesteding van activiteiten door de client in een service-gedreven contract dat wordt verloot in een streng gereguleerde competitie leidt tot onevenwichtigheid in effectieve dialoog en het delen van informatie in het consortium.

Met het oog op het optimaliseren van de omgang met de marges van de interdisciplinaire samenwerking, wordt het probleem van het 'gevangen zijn tussen samenwerking en competitie verlicht door middel van het maken van expliciete opzet voor multi-level besprekingen, waarmee efficiënte interdisciplinaire samenwerking kan leiden tot een verminderd van de transactie kosten, het verlagen van risico-aversie en het stimuleren van het delen van informatie. MTC richtlijnen voor een betere interpretatie van M & O-eisen helpt bovendien om de speerpunten in het ontwerp te zetten. Met betrekking tot de marges van interdisciplinaire samenwerking, moeten interfaces worden toegewezen aan de work scopes, om deze bruikbaar te maken voor kostenbepaling. Door het in kaart brengen van alle interfaces in work scopes, is ere en basis voor alle bijeenkomsten uiteengezet,
waarmee disciplines beter geïnformeerd worden over de levertijden in het project. Deze levertijden zijn afhankelijk van onderhandelde work package looptijden. Interfaces en overlap zullen blijven bestaan, maar door de work scopes expliciet te maken, kan hier beter op worden geanticipeerd.

**Limitaties**

Belangrijkste beperkingen van het onderzoek kunnen als volgt omschreven worden:


- In de case study, ondanks het feit dat de onderzoeker van dit onderzoek geprobeerd heeft om een waarheidsgetrouwe weergave van de dagelijkse praktijk te geven, zijn generaliseerbaarheid en het nut van de bevindingen beïnvloed door subjectieve interpretatie.

- Interviews hebben een interne validiteit van de bovengenoemde willekeurige beslissingen gebracht en maakte een beschouwing van de koppelingen tussen analyses (interne validiteit, betrouwbaarheid) mogelijk. Echter, deze treden niet in detail en kunnen niet één-op-één worden geëxtrapoleerd naar andere projecten (externe validiteit)

Bovendien zijn er drie methodologische beperkingen:

- De beperking van een single-case onderzoek is aanwezig doordat de steekproefomvang beperkt is. Slechts een relatief klein aantal deelnemers kon worden ondervraagd. Door deze kleine steekproef, is het discutabel of resultaten kunnen worden gegeneraliseerd.

- De methode die wordt gebruikt voor het verzamelen van gegevens kunnen zijn vertekend. Dit kan te wijten zijn aan de theoretische voorbereiding van het gesprek.

- Naast de methodologische beperking er ook longitudinale effecten. De beschikbare tijd om deze vraagstelling te onderzoeken is dwars van deadlines en beschikbaarheid van geïnterviewden.

- Dit thesis onderzoek geeft geen externe validiteit dat onderzoeksresultaten kunnen worden geëxtrapoleerd naar andere DBFMO design competities.

**Aanbevelingen voor Arup**

1. **Formaliseer de beoogde positie van Arup als ingenieur in DBFMO competities**

   Arup is een multidisciplinaire organisatie, betrokken bij een veelvoud aan interdisciplinaire design projecten. Zoals Hoge Raad toonde, is het belangrijk dat disciplines kleur bekennen: door het tonen van hun belangrijkste kenmerken, zullen anderen de interfaces met Arup ook ontdekken en kan er actief op zoek gegaan worden naar met samenwerking.

2. **Oefen het gebruik van het voorstel voor een verbeterde samenwerking door middel van interne workshops**

   DBFMO vereist het begrip van de verschillende paradigma's van de betrokken disciplines. Dit is iets dat het best kan worden geleerd uit de praktijk. Het delen van praktische kennis, en gebruik te maken van de verschillende discipilnaire kennis binnen Arup, zou het mogelijk maken om interdisciplinaire samenwerking te simuleren in workshops.

3. **Gebruik de schema's voor een verbeterde samenwerking voor discussiebijeenkomsten voor de oprichting van consortia**

   De opgestelde schema's kunnen worden gebruikt in consortium oprichting, door andere disciplines snel te informeren over de methodology die Arup hanteert voor consortium samenwerking.

4. **Stimuleer verder onderzoek op interdisciplinaire samenwerking in het algemeen**

   Interdisciplinaire samenwerking, verdient meer aandacht, met de opkomst van geïntegreerde contracten.
Aanbevelingen voor verder onderzoek

1. Inhoud van de werkpakketten en output

In dit onderzoek is interdisciplinaire samenwerking niet onderzocht op het niveau van de inhoud van de werkpakketten. Het doel van de werk pakketten is dat output kan worden gebruikt om kostencalculatie te doen. Uit deze tgeus, kan het verbetervoorstel worden gebruikt om werkpakketten af te kaderen, en op basis van praktische inzichten en kennis van de kosten administratie, kunnen werkpakketten worden uitgediept.

2. Positie van de client in DBFMO-wedstrijden

In dit onderzoek wordt interdisciplinaire samenwerking bekeken op procesniveau; echter, zou het de moeite waard zijn om te kijken naar de interpretatie van de output specificaties, de gunningscriteria en de dialogen, door individuele disciplines.

3. Consortium contract structuren in DBFMO wedstrijden

Verschillende mogelijkheden van verandering voor consortium contractstructuren kunnen worden aangevoerd om interdisciplinaire samenwerking te verbeteren, vanuit verschillende perspectieven, bijvoorbeeld:

- Het perspectief van EPC
- alliantiecontracten (betrokkenheid client)
- verplaatsen interfaces naar ofwel EPC of MTC

4. Het gebruik van BIM in DBFMO (ontwerp competities)

De Hoge Raad als eerste een top-down verplichte implementatie van BIM in een DBFMO in de uitvoeringsfase in Nederland. Dit heeft veel problemen met betrekking tot interdisciplinaire samenwerking op tafel gelegd. In dit licht, bidet 'BIM gebruik in DBFMO (design wedstrijden)' een uitgangspunt voor een uitgebreid onderzoek.

5. Traditionele fasering in het licht van DBFMO

Uit dit onderzoek blijkt is de traditionele fasering van bouwprojecten in DBFMO-wedstrijden van minder belang vanwege de structuur van de competitie. Termen, zoals 'voorlopig ontwerp +' of '++' zijn vernoemd naar de gevraagde detail voor competitiedocumenten. Echter, een nieuwe schaal van detail moet worden gedefinieerd.
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RESEARCH DESIGN
Research design

1. Introduction
Pressured by disappointing project results in the past, the Dutch Government property sector aims to stimulate effective and efficient and minimised risk public building construction projects (Smorenberg & Reuser, 2007). Previously, contracted parties (distinct disciplines) were employed to different sections of the building’s life-cycle, leading to non-optimal linking of disciplinary works, and non-accounting for following works, causing delay and thus additional costs (Rijksgebouwendienst, 2012b). Furthermore, success of a project often referred to the quality of the architectural design, although the project could turn out disastrous in terms of maintenance and operation of the building. In conclusion, disciplinary delivery of partial products and services in the project in distinct sections does not automatically yield the best value for money (Rijksgebouwendienst, 2012).

In creating a better linkage of disciplinary works, the choice for new tendering procedures can play an influential role: the search for an optimal mutual collaboration between contracted disciplines gave rise to a new trend in Public Private Partnerships (PPPs), namely the DBFMO contract.

DBFMO
The name DBFMO, an acronym for Design, Build, Finance, Maintenance and Operate, represents the different terms of the contract to which the contractor is obliged to carry out.

Design & Build is quite often contracted in one contract for tendering construction works. In these contracts the contractor is better able to streamline the design and build-works and can better control the related design issues. When thinking in a life-cycle for the project, it is logical to also involve maintenance and operate in the contract. By doing this, the design and build can be further coordinated towards the user-phase of the building (Smorenberg et al., 2007). Lastly, by involving finance in the contract, project specific risks are moved to the private party. The Finance-term implies that the private party will pre-finance the whole project, and after completion of the building, and after completion of the building, the client will pay an availability payment, which is dependent on the performance of the building and its services (Smorenberg et al., 2007).

Several client benefits are often assumed for tendering via a DBFMO design competition (Blayse & Manley, 2004), Akintoye et al. (2005), and Leiringer (2006):
- Competitive advantage
- Higher overall quality of the end product
- Benefits accruing from letting the private sector be innovative in its solutions.

Subscribers to DBFMO design competitions, commit their selves to integrally living up to the contract terms, for the predetermined contract period (often 30 years). In order to convey all terms, an initiating subscriber (e.g. a building contractor) looks for other disciplines (e.g. architect, engineering firm, facility management etc.) to form consortiums, to subscribe to the DBFMO tender competitions. As different disciplines collaboratively start researching DBFMO requirements by the client, discipline-crossing solutions could conceivably lead to a more integral design coming at lower expenses.

2. Problem Definition
As Straub, Prinsen & Hansen (2012) confirm, the integration of these disciplines supposedly could lead to innovations in the design competition through collaborative working between disciplines with different competences. However, there appears to be a lot of inefficiencies between the different disciplines in terms of collaboration and striving to optimise project outcomes (Sogol, 2010). Inefficiencies in interdisciplinary collaboration in public tender DBFMO design competitions obstruct the delivery of an optimal integral design. According to literature, the presupposed advantages of the DBFMO competition cannot optimally be fully effective, due to:

- “Inefficiencies between the different disciplines in terms of collaboration and the striving to optimise project outcomes” (Sogol, 2010).
- “Fragmented interests in competition sections and overall non-collaborative working” (Straub et al., 2012).
- “Disciplines can be hampered in delivering value, because by an institutionalised mind-set, budget decisions prioritise traditional cost cutting over any consideration of through-life operational value” (Leiringer, Green, & Raja, 2009).
3. Research Question and Objectives

Research Question

the main research question of this thesis research denominates:

MQ | How can interdisciplinary collaboration be optimised to face the complexity of a Dutch public tender DBFMO design competition?

In order to answer the main research question, it needs to be understood how current inefficiencies in interdisciplinary collaboration hamper the presupposed advantages of the DBFMO competition. Therefore, the following research subquestions are addressed:

Table 1 Research Subquestions (Table by Author)

<table>
<thead>
<tr>
<th>#</th>
<th>Research Subquestion</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQ.A</td>
<td>What is the theoretical context of interdisciplinary collaboration for Dutch public tender DBFMO design competitions?</td>
<td>Literature study</td>
</tr>
<tr>
<td>SQ.B</td>
<td>Where does complexity manifest in the practice of interdisciplinary collaboration in a Dutch public tender DBFMO design competitions?</td>
<td>Case study</td>
</tr>
<tr>
<td>SQ.C</td>
<td>What is the explanation for perceived complexity of interdisciplinary collaboration in Dutch public tender DBFMO design competitions?</td>
<td>Literature study</td>
</tr>
<tr>
<td>SQ.D</td>
<td>What are the instruments to optimise interdisciplinary collaboration to face the complexity of Dutch public tender DBFMO design competition?</td>
<td>Improvement proposal</td>
</tr>
<tr>
<td>SQ.E</td>
<td>How are instruments to optimise interdisciplinary collaboration evaluated by practice?</td>
<td>Evaluation (interviews)</td>
</tr>
</tbody>
</table>

Research Objectives

The main research objective of this thesis research denominates:

MO | To find roles and instruments to optimise collaboration by finding the origins of collaboration deficiencies

The research objectives can be split into three different objectives, which all together contribute to the main research objective. The three objectives are categorised according to positions, relations and margins, and are defined on basis of literature.

Table 2 Research Objectives (Table by Author)

<table>
<thead>
<tr>
<th>#</th>
<th>Research Sub Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.1</td>
<td>To find the optimal <strong>Positions</strong> in interdisciplinary collaboration</td>
</tr>
<tr>
<td></td>
<td>• To find how different strivings of disciplines to optimise project outcomes in DBFMO competitions can be reconciled (based on Sogol, 2010)</td>
</tr>
<tr>
<td></td>
<td>• To discover how fragmented interests in the competition can be pooled (based on Straub et al., 2012)</td>
</tr>
<tr>
<td>O.2</td>
<td>To find the optimal <strong>Relations</strong> in interdisciplinary collaboration</td>
</tr>
<tr>
<td></td>
<td>• To identify how inefficient collaboration between different disciplines can be improved (based on Sogol, 2010)</td>
</tr>
<tr>
<td></td>
<td>• To find how an overall non-collaborative working between disciplines can be resolved (based on Straub et al., 2012)</td>
</tr>
<tr>
<td>O.3</td>
<td>To find the optimal handling of <strong>Margins</strong> of interdisciplinary collaboration</td>
</tr>
<tr>
<td></td>
<td>• To discover how disciplines can improve value of their works, living up to the rules of the competition and consortium rules-of-play (i.e. budgetting and planning) (based on Leiringer et al., 2009)</td>
</tr>
</tbody>
</table>
4. Disclaimer
In order to further bound the research, this paragraph describes the topics or fields that will not be taken into account.

- This research does not look into the DBFMO contract from a legal point of view: The DBFMO contract varies from contract to contract, country to country, and this affects the collaboration between firms.
- The aim of this research is not to bring about all the technological deficiencies that have to be overcome in order to create a successful DBFMO collaboration. The objective is to explore and to evaluate the interdependencies and activities between stakeholders.

5. Research Methodology
This paragraph presents the research plan used in order to build the knowledge on interdisciplinary collaboration in Dutch DBFMO design competitions that is necessary to meet the research objectives described. In describing the findings from analytical research (literature, case study), and to categorise roles and instruments in the improvement proposal, the findings are presented using the following categories:

- Positions: the different aspects (e.g. interests, methods, approaches, paradigms) relating to the unique position of the discipline in interdisciplinary collaboration.
- Relations: the organisational aspects relating to the collaboration between different disciplines in interdisciplinary collaboration.
- Margins: the boundaries and side-aspects that influence interdisciplinary collaboration in a (Dutch public tender) DBFMO design competition in particular.

This distinction is chosen on basis of the researcher’s own comprehension of the study subject, and is furthermore confirmed by the distinction of Bektas (2013) in describing complexity by types of relations (i.e. methodological, institutional, and programmatic – it is referred to C.2.1).

5.1 Literature Study
The literature study explains the theoretical context from which the practice of which interdisciplinary collaboration in Dutch public tender DBFMO design competitions can be understood.

Positions in interdisciplinary collaboration have been issued in literature in the light of:

- Effective design issue finding (reasons for interdisciplinary collaboration)
- Integration & team processes (role division in interdisciplinary collaboration)
- Sequential & fragmented design (time structuring in interdisciplinary collaboration).

The aim of this part of the study is to contemplate positions within interdisciplinary collaboration as a whole, to understand the positions of disciplines within a consortium. Consecutively, relations in interdisciplinary collaboration are described within the scope of a DBFMO consortium, by explaining how the consortium is established, how relational constructs come into being and how integration is foreseen. As the first two paragraphs intend to explain the current context in Dutch building construction sector, the last paragraph describes the tension fields of working in a consortium, as researched in academic papers. Lastly, margins for interdisciplinary collaboration are outlined by describing the position and underlying interest of the client, competition procedure and DBFMO contract. These describe the constraints that eccentrically push interdisciplinary collaboration in smaller margins through the process. As DBFMO is a recently new phenomenon in the building construction industry, contemporary academic research on competitions is widespread. In this last paragraph, this research is projected on interdisciplinary collaboration within consortiums.

5.2 Case study
A case study is selected as design for this research and suits the needs for this research: interdisciplinary collaboration in DBFMO competitions differs per case and is dependent on al with the context a project is located in. Therefore it is chosen to use a single case study, to deliver specific optimisation for this project, and for other projects to learn from. First, the choice for the case study as a research method is described, and subsequently the method is more typified by means of the focus of the research strategy. Thereafter, it is described how on the one hand sources of evidence are used in collecting data, finding relations and validation, and on the other hand how literature research is used to support findings.
5.2.1 Case Study as a Research Method
The choice for a case study has its own advantages and disadvantages, depending on three conditions (Yin, 2003):

1. If 'how' or 'when' questions are posed (explanatory research)
2. The investigator has little control over the event
3. Focus is on a contemporary phenomenon within a real-life context

In case of a research into interdisciplinary DBFMO collaboration, all three conditions are fulfilled.

First, in this research question it also is questioned how a certain phenomenon (interdisciplinary analyses) can be controlled. Importantly, the research question deals with operational links needing to be traced over time, rather than mere frequencies or incidence (Yin, 2003). This demands for a qualitative research, in which a process is regarded objectively from the outside. The second and third conditions are also fulfilled: a case study is preferred in examining contemporary events, in which the relevant behaviours cannot be manipulated (Yin, 2003). Case studies stand in between histories (virtually no access to actual behavioral events) and experiments (behaviour can directly, precisely and systematically be manipulated).

5.2.1 Type of Case Study
The case study research is conducted by following a research strategy. Three core decisions were made in order to choose the suitable research strategy (Verschuren & Doorewaard, 2007): the research is descriptive, explanatory and exploratory. Inputs for these types of researches are distinct, as it uses diverse types of evidence: documents, observations and interviews (Yin, 2003). To describe the current practice of interdisciplinary DBFMO collaboration an exploratory case study strategy is used. *Hoge Raad der Nederlanden* is subject for a single-case. Looking at various aspects of interdisciplinary collaboration, multiple units of analysis will result in an embedded case study design (Yin, 2003).

5.2.2 Case Study Literature Research
A case study needs validation from literature, to support research methods and construe key variables, linkages and relationships in DBFMO collaboration. Literature is used constructively to find the questions and variables that will be subject to research, and to confirm validity of the research done, in relation to four main problems looked upon (Yin, 2003):

- What questions to pose and study?
- What is relevant data?
- What is irrelevant data?
- What data to collect and how to analyse the result?

5.2.3 Interviews
Interviews are the core activity for the case study research. It brings forward key aspects found in the DBFMO design competition, that for *Hoge Raad* not yet have been viewed and evaluated. For this case study, it is chosen to apprehend the open-ended interview in the first place. Focused question will be addressed, yet the discussion is open for introduction of new topics. The DBFMO framework relates to many activities, stakeholders, interrelations and interdependencies. Therefore it is supposed that by leaving the discussion open, new aspects (outside the investigator’s thinking frame) can be brought in by interviewers. By means of descriptive research, interview minutes were transformed into a case report which provided overview of all respondents.

5.2.4 Participant Observation
The main use of participant observation serves the following purposes. Acknowledgment by researcher of:

1. The project *Hoge Raad* in relation to other (DBFMO) projects in which Arup is involved to review the position it has taken in this particular project.
2. Involved engineers and managers in this project in relation to their positions in other projects, to understand particular roles and tasks

Yin (1984/1994) describes that in participant observation, the researcher is not merely a passive observer. Instead, the researcher assumes a variety of roles within a case study situation and may actually participate in the events being (R. Yin, 1984/1994 ).Although observing the project in hindsight, by actively studying the project documentation within Arup, and directly discussing content with others, it is seen from own interpretation which aspects are relevant. In this case study research, participant observation can only be done in retrospect. Participant-observation brings forward opportunities for collecting relevant case study data, but it also involves major problems. The most distinctive
opportunity is related to the ability to gain access to events or groups that are otherwise inaccessible to a study and the ability to perceive reality from the viewpoint of someone "inside" the case study. The major problem however is related to participant-observation have to do with the potential biases produced (see Becker (1958)). The investigator has less ability to work as an external observer and may, at times, have to assume positions or advocacy roles contrary to the interests of good social science practice.

5.3 Data Triangulation
This thesis research describes multi-perspectival analyses: the researcher considers not just the voice and perspective of the actors, but also of the relevant groups of actors and the interaction between them.

Case study research is known as a triangulated research strategy. Snow and Anderson (cited in Feagin, Orum, & Sjoberg, 1991) asserted that triangulation can be done with data, investigators, theories, and even methodologies. Stake & Savoianen (1995) stated that the protocols that are used to ensure accuracy and alternative explanations are called triangulation. The need for triangulation arises from the ethical need to confirm the validity of the processes. In case studies, this could be done by using multiple sources of data (Yin, 1984/1994). The problem in case studies is to establish meaning rather than location.

Denzin (1984) identified four types of triangulation: Data source triangulation, when the researcher looks for the data to remain the same in different contexts; Investigator triangulation, when several investigators examine the same phenomenon; Theory triangulation, when investigators with different view points interpret the same results; and methodological triangulation, when one approach is followed by another, to increase confidence in the interpretation.

In this thesis research the type of triangulation is methodological triangulation, in which it is tried to find different aspects of DBFMO interdisciplinary collaboration from different types of evidence. On the one hand, project documents offer an insight into agreements that have been formally made to guideline the collaboration process. On the other hand, interviews provide with observations from practice, as seen from various viewpoints.

5.4 Plan Validity
- Construct validity points at using correct operational measures, which will need to be checked for.
- Internal validity describes causal relationships, that are a requirement for validity in explanatory or causal studies, but not in exploratory studies.
- External validity means that the research results can be extrapolated to other fields. This type of validity is not the intended aim, however a bigger application of found conclusions do validate the research as being useful.
- Reliability describes the option of reproducing the research and come to the same results.

Below it is described how validity is accomplished in this thesis research:

Table 3 Types of Validity per Chapter (Table by Author)

<table>
<thead>
<tr>
<th>Part</th>
<th>Literature study</th>
<th>External validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A,C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Project</td>
<td>construct validity, internal validity</td>
</tr>
<tr>
<td>B, E</td>
<td>documentation</td>
<td></td>
</tr>
<tr>
<td>Part</td>
<td>Interviews</td>
<td>Internal validity, reliability</td>
</tr>
<tr>
<td>B, E</td>
<td>Participant</td>
<td>External validity</td>
</tr>
<tr>
<td></td>
<td>observation</td>
<td></td>
</tr>
</tbody>
</table>

5.5 Aggregation of case study and literature study
Using the findings from theory (literature study) and practice (case study) conclusions are drawn on perceived phenomena in interdisciplinary collaboration in DBFMO design competitions. These phenomena are described from literature: an explanation to observed customs is given, from an understanding of other processes in the construction sector. By means of literature study, evidence is compiled for describing phenomena, on basis of which the similarities are concluded. Inductive research “involves the search for pattern from observation and the development of explanations – theories – for those patterns through series of hypotheses” (Bernard, 2011, p.7). Observations from Hoge Raad were used to induce vested theories on process and collaboration.
5.6 Improvement Proposal
On basis of an understanding of the described phenomena, an improvement for the collaboration is described. Roles and instruments (directives, process tree, meetings, strategies etc.) are introduced to face hindrances due to these phenomena. Using the practical directions given by interviews from Hoge Raad, and mirroring these to the complexities, roles and instruments to optimise interdisciplinary collaboration are created.

5.7 Reflection
The improvement proposal is tested by means of reflection interviews with the interviewees from the Hoge Raad project. From experience of the actual process run through in the Hoge Raad, it is reflected on the instruments for an optimised interdisciplinary collaboration. Comments are described, to further highlight the peculiarities of the DBFMO collaboration process.

6. Thesis Content Diagram

Figure 1 Thesis Content Table (Graph by Author)
### 7. Glossary

<table>
<thead>
<tr>
<th><strong>(Building) Life-cycle</strong></th>
<th>The view of a building over the course of its entire life - in other words, viewing it not just as an operational building, but also taking into account the design, construction, operation, demolition and waste treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(Value Chain) Instruments</strong></td>
<td>The activities in the value chain by which a firm tries to create value for the market</td>
</tr>
<tr>
<td><strong>Award Criteria</strong></td>
<td>List of criteria for the design, issued by the Rijksvastgoedbedrijf, by which a consortium can score points during the competition</td>
</tr>
<tr>
<td><strong>Best and Final Offer (BAFO)</strong></td>
<td>Final issue of the competition tender by the consortium</td>
</tr>
<tr>
<td><strong>CAPEX/OPEX</strong></td>
<td>Capital expenditures (Initial construction costs)/operational expenditures (costs during operational period)</td>
</tr>
<tr>
<td><strong>DBFMO (contract)</strong></td>
<td>An acronym for Design, Build, Finance, Maintenance and Operate, represents the different terms of the contract to which the tenderer is obliged to carry out</td>
</tr>
<tr>
<td><strong>DBFMO (contract) term</strong></td>
<td>The specific term of the contract (i.e. Design, Build, Finance, Maintenance and Operate) to which the tenderer is obliged to carry out</td>
</tr>
<tr>
<td><strong>DBFMO design competition</strong></td>
<td>Tender competition, in this case held by the Rijksvastgoedbedrijf, for the award of a DBFMO contract</td>
</tr>
</tbody>
</table>
| **DBFMO terms** | - **Design**: design quality, win the tender.  
- **Build**: constructability, construction planning and (fire) safety of the construction.  
- **Finance**: quantities and prices, procurement and planning.  
- **Maintenance**: possibilities for cleaning, replacement.  
- **Operate**: building security, construction flexibility/adaptability  
- **BM**: maintenance in relation to construction choices  
- **MO**: maintenance in relation to flexibility/adaptability. |
| **Design (detail)** | The total of (preliminary) design output which can be communicated with the client |
| **Design Vision** | The total of design ideas/concepts that shape the design strategy |
| **Disciplinary knowledge sharing** | Making other disciplines part of works done by one discipline |
| **Domains** | The realms in which disciplines perform their works, e.g. building, planning, financibility, fire safety, structural, façade, security. Domains can pertain to more disciplines, e.g. fire safety is primarily the domain of the fire engineer, though also that of the architect |
| **Economically Most Attractive Tender (EMAT)** | Scoring system for competition tenders that selects the best tender in price/quality |
| **Engineering, Procurement & Construction (EPC)** | Company that is head responsible for the Design & Build-phase and takes care of all design and construction arrangements |
| **Instruments** | The roles, directives, meeting structures and work scopes that are altered or introduced to promote an optimised interdisciplinary collaboration |
| **Interdisciplinary analyses** | Analyses undertaken by two or more disciplines that can only be accomplished successfully by virtue of working together |
| **Interdisciplinary collaboration** | Collaboration between two or more disciplines that have different backgrounds, paradigms, etc. within the building construction industry |
| **Maintenance & Transfer Contract (MTC)** | Company that is head responsible for the Exploitation-phase and takes care of the maintenance and operation arrangements |
| **Method (output)** | The means used in order to generate output, i.e. analysis & design tools |
| **Output Specification** | Programme of requirement (formal) issued by the Rijksvastgoedbedrijf with the demands for the output of design and services |
| **Public Private Partnership** | Government service or private business venture which is funded and operated through a partnership of government and private party |
| **Rijksvastgoedbedrijf** | Dutch Government Building Agency (previously: Rijksgebouwendienst) |
| **Special Purpose Company (SPC)** | Leading company in the consortium, which takes care of formal accounting and contractual arrangements. (Sometimes referred to as: Special Purpose Vehicle (SPV)) |
| **Strategic flow** | Design decisions anticipated to make the design competition-winning, which follow a special trajectory throughout the design process |
| **Strategy 2 Win** | Strategic plan, decided on in coordination meetings, which describes steps to be taken (i.e. design strategy, organisational strategy, business strategy, etc.) to win the competition |
| **Value Chain** | Chain of activities that a firm operating in a specific industry performs in order to deliver a valuable product or service for the market |
| **Work packages** | Analyses and other design activities that are strongly interrelated bundled together |
| **Work scope** | (previous) strategic flow formalised in a workflow that describes linkages and iterations between work packages. Work scopes are established for design choices that are anticipated to be award-winning or need special attention, and are controlled by the custodian throughout the competition |
PART I
COMPLEXITY OF CURRENT
DBFMO COMPETITIONS

A.
THEORETICAL CONTEXT

“Consortium establishment is a mating dance: parties start probing for consortium partners, and display their selling points to lure them.”
(Kok, 2015)
A. Theoretical Context

A.1 Introduction

SQ.A What is the theoretical context of interdisciplinary collaboration for Dutch public tender DBFMO design competitions?

In this literature study the theoretical context is explicated which founds the practice in which interdisciplinary collaboration in Dutch public tender DBFMO design competitions manifests. In order to comprehend the different aspects at stake, the chapter is subdivided in following paragraphs:

A.2 Positions in Interdisciplinary Collaboration: Disciplines

A.3 Relations in Interdisciplinary Collaboration: DBFMO Collaboration

A.4 Margins for Interdisciplinary Collaboration: Public Tender DBFMO Competitions

A.5 Discussion

A.6 Conclusion

Using this subdivision, interdisciplinary collaboration is analysed to the basics of position, relations and margins. By understanding these basics from a theoretical context, it gives the researcher confidence in judging observations made in the case study.

A.2 Positions in Interdisciplinary Collaboration: Disciplines

A.2.1 Reasons for Interdisciplinary Collaboration

In construction projects both the client, the contractor and other subcontractors are concerned with the magnitude and pattern of their risks (Smith & Sadler-Smith, 2006). Designing parties (i.e. architect, engineer etc.) have an interest in knowing the risks of their designs, either to serve the party by whom they are commissioned, or simply to know if cutting-edge concepts that have been induced are feasible to create. In other words: all stakeholders have an urge to get grip on the design process.

Qualitative analyses describe techniques for understanding risks of the design and their potential influence, and comprise: identification, assessment, ranking, sorting, classifying, allocating ownership and judging the probability and impact of potential risks (Smith et al., 2006). This lays the foundation for all the subsequent stages in that process, including quantitative analyses: thorough studies of the uncertainties associated with budgets and timescales (Smith et al., 2006). At this early stage of project development, it will highlight areas where more information is needed and frequently generate imaginative responses to potential problems, thereby reducing risk.

Although individual stakeholder interests can be differ in goals (compare architects, construction companies, and engineers), in scales (compare building materials to the build environment), and scientific disciplines (compare structural engineering (physics) to building regulation (law)), they often serve a common higher goal (an integrated building) (Lasvaux et al., 2014). Some analyses bring together different disciplines, on the interface between different domains (e.g. façade relates to architecture, building physics and structural design). Smith et al. (2006) describe that the common goal of all disciplines is to exert control over the activities, which contribute to the stakeholder’s investment or fee. The possibility to bring changes to the design diminishes as the project proceeds. There are two key events on which control can be exercised (Smith et al., 2006):

- Sanction commitment to a project of particular characteristics
- Contract award commitment to contractors and major cost expenditure.

It follows that prior to these two commitments clients have ample opportunity to exercise control. They make decisions to define the organisation and procedures required for the execution of a project. These decisions affect the responsibilities of the parties; they influence the control of design, construction, commissioning, change and risk; hence they affect cost, time and quality (Smith et al., 2006).

A.2.2 Role Division in Interdisciplinary Collaboration

In contemporary construction projects, integration of disciplines is common: the current building practice has such a complexity that design teams have to integrate their works in order to overcome certain project risks. Collaboration is impeded because integrated design team members come from different organisations or practices and duplicate each other’s efforts, and many problems often fail to be resolved either quickly or to anyone’s satisfaction (Zager, 2002). Chiocchio, Forgues, Paradis, & Iordanova (2011) describe how integrated design teams strive to flatten the decision-making structure. Different disciplines claim an egalitarian role in the decision-making and project control process. Chiocchio et al. (2011)
exemplifies the architect’s role, which according to them must evolve from a hierarchically inclined decision maker to a role of mediator and problem solver. Moreover, instead of providing rigid solutions to architectural demands, engineers must learn to inject their knowledge and skills earlier in the design process. In conclusion, Chiocchio et al. (2011) affirm that to make interdisciplinary collaboration possible, traditional roles have to shift.

The set-up of interdisciplinary collaboration, in which roles and tasks can be divided or collaboratively undertaken on basis of reciprocity, have become more complex. Multidisciplinary teams refer to situations where several different professionals work on the same project but independently or in parallel; as such, it is an additive model of taskwork and teamwork (D’Amour, Ferrada-Videla, San Martin Rodriguez, & Beaulieu, 2005). Interdisciplinary teams imply a greater degree of collaboration between team members in an effort to integrate and translate themes and schemes shared by team members. The interdisciplinary team is based on an integration of the knowledge and expertise of each professional, so that solutions to complex problems can be proposed. The building industry is particularly sensitive to problems with team processes: team efficiency problems increase waste and rework in architectural building design management (Rounce, 1998). Rounce (p. 201) added, “the competitive edge in the building industry depends on the quality of the process”. Notably, processes predict team performance (Kozlowski & Bell, 2003; LePine, Piccolo, Jackson, Mathieu, & Saul, 2008). Also, different disciplines are distributed to various companies. Lähr & Bletzinger (2005) name as the crucial problem that disciplinary knowledge is shared insufficiently, and as parties usually don’t work together for any longer than the duration of one project, a misfit between parties will continue to exist. Bektas (2013) names that sharing disciplinary (domain) knowledge is needed in order to realise the technically and socially complex products, which are the result of interdisciplinary collaboration. Projects incrementally carry a higher level of complexity in particular due to their programs, collaboration forms, budget and required technical knowledge. Bektas (2013) names as problems:

1. Disciplinary knowledge sharing among actors in the design process is limited
2. Managers are not sufficiently aware of the importance of disciplinary knowledge sharing

For the first problem, Newstetter & McCracken (2001) suggest that sharing knowledge necessitates learning how to behave under the new context of interdisciplinary teams, learning new roles and skills, and unlearning old habits and behaviors. Each design professional is only liable for the results in his or her own specialty. The second problem named by Bektas (2013), is explained by Dupagne (1991) by ‘a lack of shared leadership and accountability for the overall project outcome’.

According to Rounce (1998) interdisciplinary collaboration is prone to conflicts, given the adversarial relationships between contractors and design teams and an unwillingness to work with people of divergent views or different design disciplines. Specifically, the design phase is prone to issues with personalities (Arditi & Gunaydin, 1998), such as adopting a political or protectionism stance on quality problems and inability to recognise quality failures due to pride (Rounce, 1998). Teams provide an interpersonal context in which conflicts and ways to manage them emerge (Alper, Tjosvold, & Law, 2000). Conflicts start with perceived incompatibilities or discrepant views among the parties involved and evolve into behavioural reactions (Jehn & Bendersky, 2003). In terms of determinants, early conflict scholars asserted that conflict follows from a breakdown in cooperation (Jehn & Bendersky, 2003), suggesting certain forms of social processes are closely linked to conflicts.

A lack of clarity in describing objectives or requirements, lack of coordination of roles and responsibilities at project inception, poor communication between designers, and problems coordinating between disciplines later on are well-known issues (Rounce, 1998). Design scholars Kim and Maher (2008) emphasised that design disciplines involved in collaboration spend a great deal of time on “cognitive synchronisation” (p. 226) characterised by rich bidirectional communication, such as asking for clarifications and analysing the problem, in order to gain a shared understanding of roles and instruments to optimise interdisciplinary collaboration

### A.2.3 Time Structuring in Interdisciplinary Collaboration

In (inter)disciplinary analyses time plays an important role in controlling the project risks, by linking the interdependent risks along the process (McGrath, 1991). Moreover, it is crucial for collaboration: team members’ perceptions of goal interdependence affect how they act with one another, and these interactions are sustained for the project lifetime (Young, 2003, p. 83). Project planning can be established on basis of analyses of resources and costs, to communicate to all parties in a project about the outcomes of the analyses, to identify sequences of analyses/activities and to draw attention to potential problem areas. The
successful realisation of a project will depend greatly on careful planning and continuous monitoring and updating (Smith et al., 2006). Interestingly, because integrated design teams work in a project environment, it is possible to overlay the development of the team onto the progression of the project. Here, milestones are crucial elements. Milestones are external events that signal phase changes and help determine if the project is on time, within budget, and on specification (Project Management Institute, 2008).

Milestones are mapped in a programme that will form the basis of the plan. Sequences of analyses, that are defined at project start, are linked on a timescale to ensure that priorities are identified and that efficient use is made of expensive and/or scarce resources (PMI, 2008). Within each project, interfaces between disciplines must be identified to signify the sequences. Pullar (2006, p. 100) defines the collaborative building design process “as an iterative flow of interdependent decisions of different design professionals”. This description highlights the cognitive dynamics involved between team members across time. However, it leaves unanswered the questions of ‘how to manage the flow of decisions’ and ‘how to manage the flow of interdependent actions that define the design task across disciplines’.

Sequential and fragmented design is deeply rooted in professional codes of practice and bodies of knowledge (Koskela, Howell, and Lichtig (2006)). Professional associations maintain tight boundaries between business, design, and construction knowledge. Koskela et al. (2006) contend that the incapacity of the industry to move from sequential to integrated design results from the adversarial business context created by transactional contracting methods. They create barriers that compromise the successful resolution of conflicts or contradictions resulting from collaborative work (Brown & Duguid, 2001). Interdisciplinary analyses as such, are not attractive for participating disciplines, because of the lack of contractual coverage and thus remuneration (Koskela et al., 2006)

A.3 Relations in Interdisciplinary Collaboration: DBFMO Consortium

A.3.1 Establishment of a Consortium

A consortium can be formed by different organisations. Dependent on the complexity of a project in many cases a financier, a contractor, a technical maintenance company, and facility management companies are assembled (Pan, 2009). Besides, in most cases there is a direct collaboration with an architect. Lastly, other organisations such as financial institutions, legal professionals and consultants are included; this differs per project.

Pan (2009) mentions that every organisation buys its own share in the consortium. It is also possible that the consortium conveys two, three or more suborganisations. In unique cases the consortium is formed by a single organisation. Using an allocation key, parties establish the mutual responsibilities for the different services, by which parties buy their share in the consortium (Miersis, 2009). For every consortium partner the DBFMO contract is an interesting deal: parties ensure the availability of work and thus income for a long contract period (Pan, 2009). Tasks for consortium parties are decided using the output specification by the client and the agreements made within the consortium (Jansen, 2009). The importance of the clear definition of roles and responsibilities of delegates in the project organisation is acknowledged as this positively influences the qualitative performance of the process. The risk is apparent that the managing party has difficulty in finding the balance between ‘satisfying the client’ and ‘managing the process properly.’ (Pan, 2009)

A.3.2 Relational Constructs in a Consortium

The relation between the different companies within the consortium can be seen in figure 2.

Special Purpose Company (SPC)

The Special Purpose Company (Sometimes referred to as: Special Purpose Vehicle (SPV)) is the leading company in the consortium, which takes care of formal accounting and contractual arrangements. Consortiums invariably set up SPCs after being selected to participate in the competition, and members of the consortium can become the shareholders of the SPC (Grunenberg & Hughes, 2004). It is the responsibility of the SPC to:

- Maintain the relations within the consortium collaboration: management of the Engineering, Procurement & Construction (EPC) – contract for the Design & Build and the Measured Term Contract (MTC) for Maintenance & Operation.
- Hold the so-called interface risks (Klijn, 2010): risks of the design that might crossover from Design & Build to Maintenance & Operate are thus covered. These are mutually outsourced by the SPC.
- To account in the design for the costs of maintenance and operation for the complete life-cycle financing by the market (Klijn, 2010)

At the moment of construction completion, the client does not remunerate the SPC yet; availability payments are fulfilled on basis of the performance of the SPC in the exploitation phase.
(External) financers

(External) financers are dependent, for repayment of their loans, almost completely on the remuneration of the SPC by the client (Klijn, 2010). Importantly, there is no real estate that serves as collateral for the financers. The client decides normally to retain the property of the building. Collateral for the financers thus has to be found in loans. They therefore strive to exclude as many risks for the SPC (and for themselves). This is ensured by the following (Klijn, 2010):

- Financers have a great involvement in the tender procedure and contract establishment
- Financers see to it that risks are shifted to subcontractors of the SPC (i.e. EPC and MTC) and other stakeholders.
- Financers accurately monitor the project development to ensure a constant positive cash flow

Moreover, by means of direct agreements, stipulated step-in rights give the financers the possibility to appoint themselves to the position of the SPC and to (temporarily) take over the contract (Klijn, 2010).

The large and influential role financers have in the competition and following phases (contract close and financial close) is accompanied by high transaction costs for the DBFMO competition. Therefore, only projects with sufficient critical mass are studied for appropriateness for a DBFMO contract.

Engineering, Procurement & Construction (EPC)

Engineering, procurement and construction (EPC) contracts for DBFMOs are structured very similarly to turnkey design-build contracts (Becker & Murphy, 2008): a type of project that is constructed so that it could be sold to any buyer as a completed product. In DBFMOs, the EPC contracts are commonly used in the construction of larger-scale project-financed buildings, infrastructure and energy projects. The contract governs various elements of the construction of the building from procurement of building elements to the installation of MEP systems (Becker & Murphy, 2008). According to Becker & Murphy (2008), other contractual approaches can be included, such as separate supply contracts for specific building elements, a separate design agreement and a construction contract with or without a further project management agreement.

The choice of contracting approach depends on a number of factors including the time available, the (external) financers requirements and the identity of the contractor(s). The major advantage of the EPC contract over the other possible approaches is that it provides for a single point of responsibility and a single point of contact between the project developer and the contractor.

1. An EPC contract provisions are crucial to ensuring the “bankability” or “financeability” performance standards set by the SPC.
2. Responsibilities of the EPC contractor include:
   - Obtaining compliance certificates in respect to the construction.
   - Technical compliance requirement, such as meeting safety standards (Becker & Murphy, 2008).

Maintenance & Transfer Contract (MTC)

Parties that ensure the maintenance and operation responsibilities of the DBFMO contract are fulfilled compile the Maintenance & Transfer Contract

![Figure 2 Organisation Contractual Structures for DBFMO Consortiums (Graph by Author)]
(MTC). This implies that the MTC supervises the project with (side) facilities is composed as such, that the project after the design and construction is fit for maintenance and operation for future use by the client (Koster, Hoge, Geerling, Perie, van Baashank, Prinsen, 2008). Responsibilities for the MTC regular maintenance convey regular maintenance, but also large repair and replacement investments. In a (maintenance and) service plan, the contractor establishes the obligations for the consortium. The contractor periodically revises the service plan, and because maintenance- and operation works can obstruct the availability of services, coordination with the rebate mechanism is an important prerequisite (Koster et al. 2008).

A.3.3 Integration in a Consortium

In the establishment of consortiums, the structural integration of multiple perspectives in the process positively benefits this. Moreover the process is also influenced by the active integration of stakeholders to increases the support and commitment. This in its turn increases the stakeholder’s perception that they can influence the process. Despite this positive character of the active integration of stakeholders and different delegates of one stakeholder, it is perceived that the effort can be diminished when the stakeholders cannot relate to the substance of the process. This can be related to the lack of requirements traceability in the process. This concept refers to the ability to describe and follow the life of a requirement, in both a forwards and backwards direction (Gotel & Finkelstein, 1994) and is not discussed to a significant extent in the literature on requirements management. A requirements is traceable if the origin of each of its requirements is clear and if it facilitates the referencing of each requirement.

Heuckelum et al. (2007) describes three tension fields in fulfilling the requirement, which are apparent due to different perspectives within a consortium:

1. **Company as an individual**: Aspects that play a role here are whether or not a company has relationships with companies outside the company.
2. **Between companies in a consortium**: two companies are able to cooperate, and focuses on possible conflicts because one company wants to learn from the other.
3. **Consortium as a whole**: the consortium as a whole has to work like a single engine, possible existing conflicts have to be resolved.

A.4 Margins for Interdisciplinary Collaboration: Public Tender DBFMO Competitions

A.4.1 Client Position

From the viewpoint of public responsibility and a responsible allocation of public means, the assignment for the development of the public project needs to be tendered by the government in competition (Karsten, 2009): when the value of services exceeds €206.000, local governmental bodies in European Union (EU) countries have to call for tenders in accordance with the EU directive, which specifies tender procedures (R. Kroese, 2009). European Tender Directives however, do not give concrete instructions for the establishment of Public Private Partnerships and the choice of the private partner in that frame, nor for assignments to other parties that are consequence of the PPPs (Karsten, 2009).

Implementing the procurement regulations every commissioning client in Europe organises a tender for the selection of a partner that provides certain services and/or construct works (Hoezen & Volker, 2012). In the Netherlands, the Rijksvastgoedbedrijf (Government Building Agency, formerly: Rijksvastgoedbedrijf) is responsible for the governmental real estate (Rijksgebouwendienst, 2012a). For the construction of their buildings the Rijksvastgoedbedrijf, as a public client, introduced the DBFMO contract for tendering an accommodation service instead of a building, delivered as a product at a certain moment in time (Straub et al., 2012). In a DBFMO competition the client refrains itself from involvement in the construction design project and conducts the competition from a distance (Verweij & Reynaers, 2014). The public commissioning client has to apply the principles of objectivity, transparancy and non-discrimination to select a projectpartner. This results in strict rules of the game, in which no one-to-one situation between client and contractor is allowed (Hoezen & Volker 2012).

A.4.2 Underlying Interest of Client

Within a predetermined performance specification the public client buys usable space or functionality for a certain period (Straub et al., 2012). The public government aims for sustainable, flexible and innovative housing (Rijksgebouwendienst, 2012a), and strives to counteract a surplus of planned budget and failure costs in construction projects (Verweij & Reynaers, 2014). The DBFMO contract aims to deliver an optimisation of all 5 DBFMO aspects with an efficiency gain as a result (figure 3-left). The advantage for the public government of the Public Private Partnership that is constituted by the DBFMO contract is evident: a project can achieve quality when the government discusses...
with private parties in early stages about the best way to claim their goal (Karsten, 2009). The government’s demand can be realised by means of different solutions. Every solution comes at a different price. In order to judge whether solutions are feasible, and to develop solutions and price them, considerable investments (time and money) have to be made by market parties (Karsten, 2009). For a market party, however, it is uncertain if the client really appreciates the solutions offered. This leads to the government and market parties attempting to coordinate the solution directions in which market parties can manifest best and which are acceptable for the government.

A.4.3 Competition procedure
In DBFMO competitions the government’s role is restricted to facilitating, e.g. the usage of their legal and regulatory framework in the context of planning a project with (partial) public function (Karsten, 2009). The factual development of the project occurs at the expense and risk for the private parties (Karsten, 2009). In order to shield all risks the client faces in its liaisons with contractors, certain elements are introduced to the DBFMO competition:

Output Specification:
The government approaches the market with an output specification that only comprises of basic and functional demands (Karsten, 2009): this formulates which properties the project needs to have. Market parties are free to decide how the project can be realised in an optimal manner, and can set a price for the offered performance. The government consecutively can compare the different offers in order to decide which one is the most attractive (Karsten, 2009). Requirements concern the total work environment, i.e. all spaces with required building services and facilities (Jansen, 2009). This entails e.g. temperature, light intensity and burglary protection. Moreover, requirements for furniture are incorporated. Other requirements concern the compilation of the catering services, cleaning of the building, or the waiting time at the reception (Bergsma, 2007). The output specification can be refined by the client along the competition period (Jansen, 2009).

Award Criteria:
Competitors can earn points by offering solutions that proficiently contribute to the focal points of the client explicitly. These are points the client ‘attaches value to’, and such focal points comprise ‘latent’ requests for e.g. the flexibility of the building, a communicative working environment or a ‘beautiful’ design (Rijksgebouwendienst, 2012c).

![Figure 3 Illustration showing the search of the Rijksoverheid (Dutch Public Government) to award a DBFMO contract to a consortium (left), and the periodical remuneration (right) (Rekenkamer, 2013)](image-url)
The award criteria challenge the competitor to invent solutions for the design, by which the competitor can distinguish himself from others (Rijksgebouwendienst, 2012c). The criteria are scalable: the one competitor can offer a higher quality, by which more points per award criterion are earned.

**Competitive Dialogues:**

A ‘competitive dialogue’ is procedure in which any economic operator may request to participate and whereby the contracting authority conducts a dialogue with the candidates, with the aim of developing one or more suitable alternatives capable of meeting its requirements, on basis of which the candidates chosen are invited to tender (Hoezen & Volker, 2012). The client’s aim is to comprehend the solutions the different parties offer, on basis of which he can judge if the competitor has given a serious and professional embodiment to the request (Rijksgebouwendienst, 2012d). Furthermore, client tests in this phase the minimum requirements, award criteria and performance requirements on its technical, financial and juridical feasibility. The solutions presented by the competitors at minimum have to comply with the output specifications. The dialogue rounds are (for most DBFMO competitions) subdivided in three phases (Rijksgebouwendienst, 2012d):

1. **Information phase:** the client explicates what the request is and how the procedure will be followed. By doing this, the client tests if his request is formulated well and if there are questions on the competitor’s side. At the end of this phase the client selects the competitors for tendering; a reduction in number of competitors is optional.

2. **Vision phase:** this dialogue addresses the terrain, the build environment and services. The competitor construes his vision on the client’s assignment. Possible solutions are discussed.

3. **Indicative offer:** in this phase the preliminary design, including the service plan, price and financing plan is requested. From this, it is assessed what the aspects ‘forcing up the price’ are and consecutively the client’s request is adjusted. This dialogue phase concludes with an indicative offer.

**Best and Final Offer (BAFO):**

After completion of the dialogue phases, parties are invited to make their Best and Final Offer (BAFO). The Government Building Agency (as the client’s commissioner) and the client compile expert teams, who evaluate (Rijksgebouwendienst, 2012c). Expert teams compare the offers to the output specifications and judge the completeness and validity. In addition they award points to the extent by which the offer complies with the award criteria, set out in the tender guidelines (Rijksgebouwendienst, 2012c). Expert teams evaluate the tender offers on price and quality, by answering the following questions (Rijksgebouwendienst, 2012c):

- Which added value does the solution offer in relation to the minimum (output specifications)?
- How is the added value appreciated in terms of points?
- Which competitor scores highest on the (weighted) award criteria?

**A.4.3 DBFMO Contract**

**Contract and Financial Close**

Finally, on basis of the expert’s conclusions, the Government Building Agency decides which competitor has brought the Economically Most Attractive Tender (EMAT). This party is then invited to sign a contract, the alleged contract close (Rijksgebouwendienst, 2012c). Shortly after the contract close, a financial close follows, in which the definitive availability payment is decided on. Importantly, during the financial close, the interest percentage for the project is set.

**Supply Agreement**

Supply agreements by the Government Building Agency and the end users are signed, which comprise arrangements for the construction and exploitation phase, e.g. in the construction phase the mandate for the GBA to represent the State (user) (Rijksgebouwendienst, 2012c).

**Availability Payment**

In the output specification the term of the project and the final quality level is described, along with the requirements for the services of the contractor (Jansen, 2009). The remuneration for the consortium will be 100% in case of optimal service facilitation; in case of default the rebate mechanism calculates the discount of remuneration (figure 3 – right). The mechanism monitors compliance. The subdivision of the availability payment for all parties within the consortium is awarded using an allocation key. Due to the discounts introduced, the consortium is incented to deliver the performances according the agreed quality level, and to resolve certain problems (Jansen, 2009). However, the total discount has to be relative to the maximum remuneration. The mechanism implies that penalties will increment for the magnitude of the malfunction; when the consortium does not succeed to resolve the issue a penalty will follow (Rijksgebouwendienst, 2006).
A.5 Discussion

Positions in Interdisciplinary Collaboration

Interdisciplinary collaboration is needed to collaboratively find the risks of a design. As Lasvaux et al. (2014) asserts, an integrated building can only be designed by virtue of merging different disciplinary interests. These interests can differ in goals, scales and scientific discipline, but often serve a common higher goal. As Smith (2006) asserts, the importance of interdisciplinary collaboration must be seen in relation to control over the design. Control can be exercised on key events, i.e. sanction and contract award commitment. Prior to these two commitments clients control the procedure, which affects the responsibility of parties: they influence the control of design, construction, commissioning, change and risk (Smith, 2006).

Clearly, a systematic approach is needed to structure the different roles, however, as Chiocchio et al. (2011) discuss, the decision-making and project control process needs to be flattened. Therefore, Chiocchio et al. (2012) declare that it is necessary that traditional roles of disciplines shift, to give room for a systematic approach. Newstetter & McCracken (2001) underline this, by saying that in order to behave under the new contest of interdisciplinary teams, new roles and skills have to be learnt to promote ‘shared leadership and accountability for the overall project outcome’ as Dupagne (1991). As Rounce (1998) mentions, interdisciplinary collaboration is in particular sensitive to problems with team processes. Lähr & Bletzinger (2005) stress as the underlying reason that disciplinary knowledge is shared insufficiently, and as parties usually do not work together for any longer than the duration of one project, a misfit between parties will continue to exist. In her doctoral thesis, Bektas (2013) brings up as reasons for problems that (1.) disciplinary knowledge sharing among actors in the design process is limited and that (2.) managers are not sufficiently aware of the importance of disciplinary knowledge sharing.

Conflict between different disciplines is mentioned as a serious hamper for interdisciplinary collaboration. Conflicts arise due to a breakdown in cooperation (Jehn & Bendersky, 2003) and a lack of clarity in describing roles and responsibilities (Rounce, 1998) (choices regarding taskwork) are named as the foremost reasons for conflict. Time structuring plays an important role in the success of interdisciplinary collaboration: The successful realisation of a project will depend greatly on careful planning and continuous monitoring and updating (Smith, 2006). The purpose of planning is therefore to:

- persuade disciplines to perform analyses before they delay the operations of other disciplines, and in such a sequence that the best use is made of available resources and improve decision-making in the event of change.
- To expose the interfaces between disciplines, that have to be included in the programme and managed effectively.

The absence or inadequacy of synchronisation in interdisciplinary collaboration, according to Koskela et al. (2006), can be imputed to the sequential and fragmented design being deeply rooted in profession. This can be attributed to adversial business contexts (created by transactional contracting methods) and insufficient time structuring. Interdisciplinary analyses as such, are not attractive for participating disciplines, because of the lack of contractual coverage and thus remuneration (Koskela et al., 2006).

Relations in Interdisciplinary Collaboration

Different researches that have been done on DBFMO interdisciplinary collaboration indicate the urge of the industry to get hold on the multiplicity of different levels the DBFMO design process can (or cannot) be steered. Earlier work by Smorenberg et al. (2007) and Hoezen & Doree (2008) underline this: there is a striving to understand design issues from a broader view of interdisciplinary collaboration. This is exemplified by Pijnappel (2012), who provides with a step-wise method for integrating construction technology to integrate build-aspects, and Straub et al. (2012), who assert that M&O services should be better aligned in the design phase.

Findings from the research of Hoezen & Doree (2008) show that consortiums struggle with a number of practical issues related to the dynamics of risk avoidance, which are connected to the organisation of collaboration in a DBFMO. This adds to the conclusion of Den Hoed (2013), who denominates that management parties are having difficulties in finding balance between ‘satisfying the client’ and ‘managing the process properly’.

Smorenberg et al. (2007) mentions opportunities of such risk managment can be magnified when employing an integration of phases (at a different moment) and an integration of parties (same moment) in consortium collaboration. An integration of parties offers the possibility of overseeing involved design issues for all stakeholders in the design competition at a particular moment during interdisciplinary collaboration (Pijnappel, 2012). The research by Pijnappel (2012) contends there is an absence of coordination, due to insufficient knowledge on
integration and focus on interfaces between different disciplines and award criteria. An integration of parties along the lifespan of the DBFMO offers the possibility of structuring the demands for all lifetime phases of the DBFMO through feed-forward anticipation (Straub et al., 2012). Straub et al. (2012) conclude that the special purpose vehicle often subcontracts different activities separately, resulting in fragmented interests and non-collaborative working and that there is little contact between the maintenance and construction department and therefore the possibility of M&O parties to influence the design is minimal (Straub et al., 2012). In this case, the research by Straub et al. (2012) confirms that the contractual division between EPC and MTC, the lack of impact of the M&O parties can lead to a fragmented design, as mentioned by (Koskela et al., 2006). Lastly, regarding the detail of information sharing, Smorenberg et al. (2007) concluded that by a far-reaching integration, a consortium can excel using complementary knowledge as a strategic alliance.

Margins of Interdisciplinary Collaboration

From the viewpoint of public responsibility and a responsible allocation of public means, the assignment for the development of the public project needs to be tendered by the Dutch Rijkswaterstaat in competition (Karsten, 2009). Using the DBFMO contract, the public government aims for sustainable, flexible and innovative housing (Rgd, brochure 1), and strives to counteract a surplus of planned budget and failure costs in construction projects (Reynaers & Verweij, 2014). In DBFMO competitions the government’s role is restricted to facilitating; the factual development of the project occurs at the expense and risk for the private parties (Karsten, 2009). Risks for the client are shielded by means of different competition instruments, such as the output specification, award criteria and competitive dialogues. These instruments constrain interdisciplinary collaboration, and the effect is two-sided:

- **Positively:** the government approach the market with an output specification for the design that only comprises of basic and functional demands (Karsten, 2009) and award criteria that can be freely shaped into proficient design solutions.
- **Negatively:** the service-output specification is formulated in terms that fix requirements in narrowly defined qualitative and quantitative aspects, on basis the client’s presumption of what is an optimal solution.

In the establishment of consortiums, using an allocation key, parties establish the mutual responsibilities for the different services, by which parties buy their share in the consortium (Mieris, 2009). For every consortium partner the DBFMO contract is an interesting deal: parties ensure the availability of work and thus income for a long contract period (Pan, 2009). The importance of the clear definition of roles and responsibilities of delegates in the project organisation is acknowledged as this positively influences the qualitative performance of the process. (Den Hoed, 2013). The SPC tries to allocate the interface risks with the EPC and MTC. The contractual division between the EPC and MTC however does not bring holistic responsibility, and because of transactional contracting, it can possibly lead to a sequential and fragmented design (Koskela et al., 2006). Interdisciplinary analyses as such, are not attractive for participating disciplines, because of the lack of contractual coverage and thus remuneration (Koskela et al., 2006).

A.6 Conclusion

Research subquestion A

What is the theoretical context of interdisciplinary collaboration for Dutch public tender DBFMO design competitions?

positions in Interdisciplinary Collaboration

- To control risks of an integrated building design, interdisciplinary collaboration demands for merging disciplinary interests. The different roles in interdisciplinary collaboration have to be restructured, to flatten decision-making and project control. As such, traditional roles of disciplines must shift, to give room for a systematic approach.
- Disciplines obstructs interdisciplinary collaboration, and are due to:
  - A breakdown in cooperation
  - A lack of clarity in describing roles and responsibilities
- Problems with team processes hamper interdisciplinary collaboration. Reasons for problems are the insufficient sharing of disciplinary knowledge and managers being insufficiently aware of the importance of this. This problem continues to exist, because parties often do not collaborate longer than the duration of the project. The absence or inadequacy of synchronisation in team processes can be imputed to: a sequential and fragmented design being deeply rooted in profession, which is due to:
  - Adversial business contexts created by transactional contracting methods.
  - Insufficient time structuring (planning).
  The purpose of planning is to:
  - Persuade disciplines to perform analyses before they delay the operations of other disciplines
  - To expose the interfaces between disciplines
Relations in interdisciplinary collaboration
- There is an urge of the industry to understand the broader view of interdisciplinary collaboration to get hold on the multiplicity of different levels the DBFMO design process can (or cannot) be steered. However, the current organisational structures result in fragmented interests and non-collaborative working. There is insufficient contact between the maintenance and construction department and therefore the possibility of M&O parties to influence the design is minimal.
- The organisation of a DBFMO consortium struggles with both client satisfaction and process management. Opportunities for risk management can be magnified when employing an integration of phases and integration of parties. In current practice coordination is insufficient, due to insufficient knowledge on integration and focus on interfaces between different disciplines and award criteria.

Margins of interdisciplinary collaboration
- Risks for the client are shielded by means of different competition instruments, such as the output specification, award criteria and competitive dialogues. These instruments constrain interdisciplinary collaboration, and the effect is two-sided:
  - Positively: the government approach the market with an output specification for the design that only comprises of basic and functional demands and award criteria. This is input for the front end of the competition value chain. (figure 4 – 1.)
  - Negatively: the service-output specification is formulated in terms that fix requirements in narrowly defined qualitative and quantitative aspects. This is input for the back end of the competition value chain. (figure 4 – 2.)
- The allocation key in project financing, fences off a contractual division between the EPC and MTC. This does not bring holistic responsibility, and because of transactional contracting, it can possibly lead to a sequential and fragmented design.

In summary
Theory on positions in interdisciplinary collaboration expounds a sectional interest in the collaboration:
- Disciplinary interests have to be merged to control design risks in interdisciplinary collaboration.
- Insufficient knowledge sharing hampers team processes and can be attributed to a sequential and fragmented design, adversial business contexts and insufficient time structuring.

Theory on relations in interdisciplinary collaboration present a difference in organisational approach of parties:
- There is an urge to understand the different levels of control for the DBFMO design process, but the current organisational structures result in fragmented interests and non-collaborative working.
- The organisation of a DBFMO consortium struggles with client satisfaction and process management, due to insufficient knowledge on integration and focus on interfaces between different disciplines and award criteria.

Theory on margins of interdisciplinary collaboration exhibits a disparity between competition and collaboration:
- The client’s output specification constrains interdisciplinary collaboration, and the effect is two-sided: a basic and functional design demand (positive), and a narrowly defined service-output specification (negative) oppose.

![Figure 4 Value Chain for the DBFMO Design Competition (Graph by Author)](image-url)
B. CURRENT INTERDISCIPLINARY COLLABORATION IN DBFMO COMPETITIONS

case study hoge raad

“In consortium collaboration it can be very difficult to get thoughts in line: it can become a tribal war in which different tribes only emphasise the aspects relating to their discipline.” (Flamink, 2014)
B. Current interdisciplinary collaboration in DBFMO Competitions: Case Study Hoge Raad

B.1 Introduction Case Study

SQ.B Where does complexity manifest in the practice of interdisciplinary collaboration in a Dutch public tender DBFMO design competitions?

In this case study the practical example is in which interdisciplinary collaboration in Dutch public tender DBFMO design competitions demonstrates, by means of researching the competition for Hoge Raad der Nederlanden. The chapter has the following outline:

- B.2 Introduction DBFMO Competition Hoge Raad
- B.3 Research Content
- B.4 Positions in Interdisciplinary Collaboration: Consortium Establishment
- B.5 Relations in Interdisciplinary Collaboration: Integrating Disciplinary Views
- B.6 Margins for Interdisciplinary Collaboration: Client Demand & Competition
- B.7 Discussion
- B.8 Conclusion
- B.9 Limitations

B.2 Introduction DBFMO Competition Hoge Raad

In December 2011 the Rijksvastgoedbedrijf (Dutch Government Building Agency – previously: Rijksgebouwendienst) announced the tender for the new accommodation of the Hoge Raad der Nederlanden (Supreme Court of the Kingdom of the Netherlands). This tender was issued as a Public Private Partnership. The ministry of Justice is the public client for the new housing; the Rijksvastgoedbedrijf is the tendering authority responsible for the tender process (Rijksoverheid, 2011). The new housing site is situated on the corner between the Korte Voorhout and the Smidseplein, in the city centre of The Hague. On this location, where previously the French Embassy and an office building were situated, a new building will rise, that will present top-quality architecture and will embellish the inner city of The Hague (Rijksoverheid, 2011).

B.2.1 Client ‘s aspiration

The client’s main ambition is described by Leus (2011) as:

“The realisation of adequate accommodation for the Hoge Raad for a contract period of 30 years from the availability date on.”

The new accommodation for the Hoge Raad needs a present-day yet timeless appearance: the market party selected, is assigned to realise a high-quality and representative building (Rijksoverheid, 2011). The following stakeholders have to be accounted for in the project (Rijksoverheid, 2011):

Table 4 (Commissioned) Clients for Hoge Raad (Rijksoverheid, 2011)

<table>
<thead>
<tr>
<th>Hoge Raad (Eng: Supreme Court)</th>
<th>Building User</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directorate-General</td>
<td>Commissioner on behalf of the Ministry of Justice and Security</td>
</tr>
<tr>
<td>Justice and Law Enforcement</td>
<td>Rijksvastgoedbedrijf Government Building Agency (contracting authority on behalf of the State of The Netherlands)</td>
</tr>
<tr>
<td>Atelier Rijksbouwmeester</td>
<td>Rijksbouwmeester President Architectural Committee</td>
</tr>
<tr>
<td>Municipality of Den Haag</td>
<td>Municipality of Den Haag collaboration partner development Korte Voorhout participant Architectural Committee</td>
</tr>
</tbody>
</table>

B.2.2 Tendering Consortiums

After preselection (Dialogue phase 1), the following three consortiums were selected for the new accommodation of the Hoge Raad:

Table 5 Tendering Consortiums for Hoge Raad (PPSnetwerk, 2012)

<table>
<thead>
<tr>
<th>Hageraad</th>
<th>Brink Management &amp; Acquisitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIPS Development</td>
<td>Advies</td>
</tr>
<tr>
<td>H&amp;R BOUW</td>
<td>Wiel Arets Architects</td>
</tr>
<tr>
<td>Heijmans PPP</td>
<td>Mecanoo architects with architect:</td>
</tr>
<tr>
<td>Poort van Den Haag</td>
<td></td>
</tr>
<tr>
<td>BAM PPP B.V.</td>
<td>PGM</td>
</tr>
<tr>
<td>BAM Utiliteitsbouw</td>
<td>BAM Techniek</td>
</tr>
<tr>
<td>ISS Nederland B.V.</td>
<td>Kaan Architecten</td>
</tr>
</tbody>
</table>

The consortium this case study will be viewing upon is Poort van Den Haag, the winning consortium.
B.2.4 Competition Value Chain

In the set-up of delivering the competition tender, the consortium uses certain terms. On basis of the procedure followed, the terms can be placed in a value chain (figure 3; enlarged in Appendix A).

<table>
<thead>
<tr>
<th>Output Specification</th>
<th>Programme of requirements, set up by the Rijksvastgoedbedrijf, which describes the demands for the output of design and services.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Award Criteria</td>
<td>List of criteria given by the Rijksvastgoedbedrijf, which describe the wishes for the design, by which a consortium can score points during competition.</td>
</tr>
<tr>
<td>Project Definition</td>
<td>The interpretation by the consortium of the output specification and award criteria combined.</td>
</tr>
<tr>
<td>Strategy 2 Win</td>
<td>Strategic plan, decided on in coordination meetings, which describes steps to be taken (i.e. design strategy, organisational strategy, business strategy, etc.) to win the competition.</td>
</tr>
<tr>
<td>Design Vision</td>
<td>The total of design ideas/concepts that shape the design strategy</td>
</tr>
<tr>
<td>Strategic Flow</td>
<td>Competition-winning design decisions, which follow a special trajectory throughout the design process</td>
</tr>
<tr>
<td>Normal activities</td>
<td>No changes are made for the day-to-day design activities of disciplines. These are considered the normal disciplinary design activities. These just follow the normal routine as in any other building construction project.</td>
</tr>
<tr>
<td>Method (output)</td>
<td>The means used in order to generate output, i.e. analysis &amp; design tools.</td>
</tr>
<tr>
<td>Design (detail)</td>
<td>The total of (preliminary) design output which can be communicated with the client.</td>
</tr>
</tbody>
</table>

### B.3 Research Content

#### B.3.1 Case Study Research Objectives

This case study research exhibits the collaboration process in the design competition of a (Dutch public tender) DBFMO project in practice. The main objective of this case study is to map interrelations between activities and strategies used in interdisciplinary collaboration in the Hoge Raad project and frames the interdependencies of participating parties. From this, the goal is to find out problems or deficiencies that occurred, and appoint these to interrelations/interdependencies they relate to.

#### B.3.2 Case Study Research Scope

The case study aims at the interdisciplinary collaboration that has taken place during the competition: study concentrates on the period between dialogue phase 1 and Best and Final Offer (BAFO). In the first dialogue phase, disciplines have to set up their own disciplinary works; there was little collaboration (i.e. through organisational or meeting structures) between disciplines, and importantly, the results of collaboration were insufficiently documented.

The scope of research focuses on the collaboration process between the designing parties (EPC) and service parties (MTC) involved. Therefore, the research takes into account the following:

- (Inter)Disciplinary design analyses assigned to parties, retrieved from project documentation
- Parties, retrieved from interviews & project documentation

#### B.3.3 Sources of Evidence

Project documentation is used in triangulation with interviews and own observation, to confirm assumptions asserted.

**Project Documentation**

The main use of project documentation serves the following purposes:

1. **Who does what...?** - Assertion of supposed (inter)disciplinary analyses that were set up for this competition. From the meetings, that were held from dialogue product 1 until the Best and Final Offer various tasks and responsibilities are extracted. Categorisation is made on basis of the following:

   - DBFMO term (see glossary)
   - Analysis method, Unit of Analysis
   - Request/addresssee
   - Domain
2. ... on which moment...? - Chronology of the different design activities, analyses, meetings, etc. on occurrence during project. Analyses are placed on a timeline, based on their recurrence in interdisciplinary meeting minutes. Thus, presumptions are made on what analyses led to others.

3. ... on which detail level? - Assumption of the DBFMO collaboration in the project, which will be used as a starting point in the interviews. In order to frame the actual possibility of information sharing between disciplines along the DBFMO design process, it is necessary to describe the detail level by which analyses were undertaken.

**Interviews**

The main use of interviews serves the following purposes:

1. *Who does what?*... Confirmation and evaluation of asserted (inter)disciplinary analyses that were set up for this project discussion of involvement of relevant stakeholders in the project.

2. *... on which moment...?* Confirmation of different design activities, analyses, meetings, etc. on a time line of occurrence

3. *... on which detail level?* Confirmation and evaluation of the DBFMO collaboration that is supposed to have been used in execution of the project

For an indication of the roles of the roles of parties within the consortium, reference is made to table 7. For an indication of the interviewees in the project hierarchy, reference is made to table 8, and the organogram in AA.2. The results of the interview will be qualitatively described in a narrative way, according to the recurring themes: DBFMO terms, request, reply, detail level. Hoge Raad, being a large construction project with different disciplines involved, yields interesting viewpoints and remarks. Thus, the interviews provide with substantiation and confirmation of assumptions from the project document analysis. A further description of the management roles in the project can be found in table 9.

**Table 10 Poort van Den Haag included Consortium Partners (PPSnetwerk, 2012)**

<table>
<thead>
<tr>
<th>Consortium Partners</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAM PPP</td>
<td>Tenderer, SPC</td>
</tr>
<tr>
<td>Kaan architects</td>
<td>Architecture, EPC</td>
</tr>
<tr>
<td>Arup</td>
<td>Structural, MEP eng., EPC</td>
</tr>
<tr>
<td>DGMR</td>
<td>Fire safety, building physics, sustain., EPC</td>
</tr>
<tr>
<td>BAM Utiliteitsbouw</td>
<td>Construction, Maintenance, EPC/MTC</td>
</tr>
<tr>
<td>BAM Techniek</td>
<td>Maintenance, MTC/EPC</td>
</tr>
<tr>
<td>ISS Nederland</td>
<td>Facility Management, MTC</td>
</tr>
</tbody>
</table>

Interviews were held with different participants, i.e.:

**Table 11 Interviewees Categorised per Team and Company (Table by Author)**

**EPC (Design & Build)**
- *Arup*
  - Jorn de Jong: Lead structural engineer
  - Marielle Rutten: Structural engineer
  - Christa de Vaan: MEP engineer

**BAM Utiliteitsbouw**
- Cor Notenboom: Design manager (EPC)
- Joost Wieland: Coordinator DesignBuild

**Kaan Architecten**
- Noëmi Vos: Project architect
- Luuk Dietz: Project architect

**MTC (Maintenance & Operation)**
- *BAM Techniek*
  - Marcel Kok: Commissioned exploitation manager

**ISS Integrated Facility Services**
- Wilbert Eekhof: Exploitation manager

**SPC**
- BAM PPP
  - Pieter-Martijn: Project director
  - Flamink: Project director
B.4 Positions in Interdisciplinary Collaboration: Consortium Establishment

B.4.1 Project Organisation Hierarchy

In Appendix A schemes relating to the project organisation hierarchy can be found. On the next page, smaller examples are shown, to illustrate: In figure 5 the contractual constructions made between the different companies within the consortium, and with the client are exhibited. In figure 6 the organogram for the project organisation within the consortium is shown. In the consortium, there are separate organisational constructs. Kok (2014) asserts that a segregation of structures is necessary because of the project financing. For the short-term D&B phase there are a number of terms, which come with certain risks and costs. The long-term M&O phase (exploitation) comes with different risks and costs; thus investors and banks want to separate these structures (Kok, 2014).

Special Purpose Company (SPC-F)
The Special Purpose Company (SPC) was set-up between the financial department of BAM (PPP) and investors (PGGM). The SPC serves to finance both the project’s initial and operational costs. Flamink (2014) explains that the SPC is contractually limited in its liabilities, e.g. if during exploitation rebates are granted, the SPC passes on the financial loss to the MTC.

Engineering Procurement & Construction (EPC-D&B)
The EPC serves Design & Build. Kaan (architect), Arup & DGMR (engineering) and BAM-T&U (contractor) have collaboratively designed the building during the competition and construction preparation phase. Design choices mainly affect the initial costs (CAPEX) of the building. Wieland (2015) names that for the EPC the project is (relatively) short-term, with determined rulesets set by the client and the consortium itself. This contrasts with the MTC: for them a long-term project unfolds, which cannot be completely foreseen (Kok, 2015). Rutten (2015) asserts that the collaboration in the EPC is hindered because the difference in hours spent: for the contractor the competition is a full-time project, whereas for advisors this is a part-time job, leading to imbalance in the collaboration for both.

Maintenance & Transfer Company (MTC-M&O)
The Maintenance & Operate branch of the consortium consist of ISS (maintenance) BAM T&U (maintenance & operation). ISS is not a shareholder during the exploitation (only subcontractor), because it does not want to bear life-cycle risks (Flamink, 2015). During the design competition they foresee on the consequences of design choices for the M&O aspects. These choices mainly affect the operational costs (OPEX) of the building. The exploitation phase of the building, brings life-cycle risks (e.g. risks of maintenance and operation) that the design brings about: minor design choices can have tremendous (negative) impact in the long run. On the other hand, risks could also have a positive impact: chances can be opportunized to create innovative solutions to void the negative impacts. Kok (2015) denotes that in the MTC it is tried to anticipate on these risks, and try to innovate. Scenarios are discussed, in order to frame an estimation of what possible future lies ahead during the 30 year contract term.

B.4.2 Interests in Consortium establishment

In consortium establishment, the initiator bases his choices for other participants on the chance thinks he has to yield success with another party (Kok, 2015). For an integral design, Kok (2015) mentions that the starting point is to have a uniform consortium interest. The Hoge Raad project is designed in the interest of the EPC. When the project is completed, the EPC is done, the result has been accomplished. What happens afterwards, is not their concern. However, if one consolidates this to the financial implications for the contractor firm in total (both construction and maintenance company) this has an impact: one may earn money because of a sound building construction, but may loose a multitude because of poor maintain and operationability. De Vaan (2015) explicates the differences in interest: the contractor invests knowing he will get remunerated after competition win. The interest of architects and engineers is to earn money for knowledge they sell; this is translated back to working hours of people (De Vaan, 2015). Rutten (2015) mentions that it is key that parties do not exceed their honorary early in the design process. In the DBFMO process, all parties attend the interdisciplinary meetings, costing abundant time.

MSc Thesis Joost (J.P.) van de Ven 40
Figure 5 Contractual relations within consortium and with the client (graphic by author)

Figure 6 Organisation within consortium in different meeting types (graphic by author)
B.4.3 Tribal war

The finance aspect of the DBFMO results in fragmenting the D&B en M&O undertakings contractually after competition win (see figure 6). Kok (2014) names that investors and banks want to shield the risks of D&B and M&O by isolating them. As such, the project financing has a separate structure. During the competition the parties already work in the associated teams of EPC and MTC, though legal obligations are not a factor. The contractual constructs EPC and MTC are put in place after competition win. Flamink (2015) explains how the SPC aims to be free of interface risks, by outsourcing these to the EPC and MTC. Because the EPC is only contracted for the period of construction, interface risks have to be allocated well: not-known deficiencies or design faults that emerge after the availability date, are no longer the responsibility of the EPC (Flamink, 2015).

Due to the different constructs (SPC, EPC, MTC), different departments of the contractor (BAM) are allocated in different hierarchies in the EPC respectively the MTC (Kok, 2015). All of these parties have their own individual financial targets. Because of this segregation, in the EPC BAM-T is the subcontractor of BAM-U. In work remuneration this leads to a premium over another premium, which in all fairness cannot be passed on to the client (Kok, 2015). De Jong (2015) exemplifies this by naming how the design manager has to justify expenses to BAM-U. If design choices are made, which are not efficient but are crucial for winning the competition, BAM-T is disadvantaged, because they will have to make more expenses. As such, conflict emerges within the contractor mother concern: the interests and incentives of the contractor departments are fragmented (Kok, 2015).

De Vaan (2015) broadens the issue by including also the other parties: also the advising parties have their targets; if this does not fit with the budget, they will combat this by making the design more economical in their perspective. Rutten (2015) stresses the importance for the process that subparties are responsible for partial budgets; the budget is a coherence of different disciplines. If parties are responsible for the investment cost of a single part of the budget, the party will automatically try to fight only for the money, and they become less open to consortium decisions.

Figure 7 Division in Consortium Companies and Shareholders (Own Illustration)
B.5 Relations in Interdisciplinary Collaboration: Integrating Disciplinary Views

B.5.1 Integration

Integration of Parties

The DBFMO process touches upon such a multiplicity of aspects, that it is almost impossible to oversee the full spectrum of ongoing activities. Wieland (2014) gives an example: if for structural reasons BAM-U uses numerous amounts of (stainless) steel, this will affect the GreenCalc calculations calculated by DGMR. Eekhof (2014) discusses how M&O parties can already contribute ideas in the very beginning, on how to design the building efficiently to perform services later. This will influence the services for a period of 30 years. Wieland (2014) mentions that the easiest approach is that everyone can answer in their own pattern. Although the exact analysis question should be bound per discipline, Wieland names it would be an improvement if disciplines could involve the perspective of 30 years maintenance & operation in their disciplinary answers.

The before mentioned implies an integration of phases, but in this case a party would singly research a design issue and shares this with the whole group, for another party to start his research on basis of this. Dietz (2014) mentions that to a larger extent design decisions were made on negotiations in meetings, rather than on basis of outcomes of analyses presented by a discipline. Eekhof (2014) explicates the new roles parties have to play. He further mentions that the original designing parties are used to building designing, and they will just start up their own ‘known’ processes. These often become leading. Kok (2015) acknowledges that integrity of the design can be improved. After competition win, the EPC and MTC start working as complete distinct entities. The EPC ceases to exist after building completion. After an internal acceptance, on basis of which the EPC is discharged from its responsibilities; from then on the MTC takes over the work (Kok, 2015).

Integration of Phases

In the collaboration process, the D&B-parties were well attuned to each other, but the M&O-parties were not yet used to deliver input from the very beginning, asserts De Jong (2014). Because maintenance determines the vast majority of all costs for the DBFMO, the M&O-parties nevertheless are enforced to sharply monitor project progress. Dietz (2014) expresses the impact of M&O on the architectural design: it demands for extra functions, multifunctionality and extra storage facilities. These would normally be easily overlooked, and therefore it is good to involve the M&O parties from the very beginning on (Dietz, 2014). All aspects that are designed in the D&B-phase, have to reflect in the exploitation to be well-thought (Kok, 2014). During the exploitation period the costs and replacement moments are a direct result from choices made in the design phase. Therefore, the architect needs to be steered to make certain design choices, otherwise this could prove to be costly in the exploitation phase. In the basis, the architect in the first place will be focussed on delivering a design that meets the award criteria. Kok (2014) mentions that small margins can be made in the D&B-phase, but when it is not well consused, a big loss is made in the M&O-phase. He illustrates this by describing a design choice regarding the natural stone facade: the architect desired to use (aesthetical) sealant for jointing the natural stone tiles. In the exploitation period this would mean that after every 7 years the sealant had to be scraped out and replaced. As a result, this would have to be done 4 times during the life-cycle. Because of the carpentry work and the scaffolding, this would account for EUR 150.000 per change. The sealant was not essential, and therefore left out, saving a lot of money.

B.5.2 Meetings

Coordination Meetings

These meetings were held between the coordination manager (P.M. Flamink), design manager (C. Notenboom) and exploitation manager (M. Kok). During these meetings, the coordination of the different teams was agreed upon, and the plans made were evaluated. Flamink (2014) explains that it initially was very difficult to get thoughts in line: it resulted in a tribal war in which the different tribes only emphasised the aspects relating to their discipline. In the end it was necessary to swiftly move to a clear-cut strategy. This could either be: the economically most attractive option, the option that could be most expeditiously delivered, or the most aesthetic option – the importance lies in clearly formulating the strategy, and consequent conduct (Notenboom, 2014).

Important characteristics of the coordination meetings:
- Discussion on how to maintain speed in coordinating the tender
- Biggest stakeholders in the consortium
- Underlying incentives of all parties emerge.

Strategic Meetings

These meetings were held between the design manager or exploitation managers with the directors of the different participating parties in the EPC or MTC. The goal of these meetings was to stipulate the project vision of the consortium, and to come up with strategic choices that could win the tender from contemplation of the OS/award criteria. The results of these meetings were fed-in into disciplinary meetings.
Characteristics of the strategic meetings:

- Discussion on the design vision on basis of strategic choices
- Directors of the consortium parties being present?
- Selection/selective approach?

The strategic design team meetings, after getting directed by the coordination meeting-team, started communally researching the output specification and award criteria (Flamink, 2014). In this meetings, long before any design was made, the strategic team determined which are the focal points for the design task. These meetings established which design elements would be zoomed in (Rutten, 2014). In the strategic exploitation team meetings, discussed the progress. Wieland (2014), discusses that these people know the feasibility of design measurements from experience, and they know what the consequences are for other disciplines. Moreover, they know the strengths and weaknesses of their competitors, and thus they explore means to deliver a distinct design (De Jong, 2014). Furthermore, the strategic meetings are important to appoint how the team will work without any debate; on the level of the interdisciplinary meetings, there are too many conflicting disciplinary views; the project progresses if decision-making is already done on a strategic level (Wieland, 2014). Notenboom, in his capacity of the design manager, elaborated on their selective approach: it was necessary to think selectively to zoom in on certain registers at certain moments. He elaborates by questioning ‘How can we collaborate interdisciplinary, without introducing to many people to this meeting?’ (Notenboom, 2014). To acclaim this, only experienced people that could be considered mindful of integrity where brought together to form the ‘the core team’. Notenboom (2014) mentions that it is crucial to decide in a small committee of experienced professionals. If certain concepts are understood and found interesting by everyone in this meeting, a strategic flow emerges, and this can be decisive for the competition (Notenboom, 2014).

Wieland (2014) streses the importance of identifying the bottlenecks: Some design activities need to be distinguished from the other design activities (which will continue separately, without interference of the strategic team). De Jong accentuates strategic flows as a result of the SM: competition-winning design decisions, which follow a special trajectory throughout the design process. Rutten (2014) explicates that these flows can ‘somehow’ be anticipated for DBFMOs in general, but the exact subject of the matter is not foreseeable. Strategic choices are made on basis of the output specification and evaluating the competitors, and these have to be communicated with the design team. De Vaan (2014) underlines the importance of the architect in the strategic meetings: in a DBFMO different contractors will heavily debate the costs, and thus it is necessary to involve architects that will stand for their architectural design in order to win the competition. Dietz (2014), comments by saying that architects are quite stubborn in trying to acclaim their aesthetic design goals in these meetings, but underlines that their opinion is substantiated by accounting for other disciplines goals. Notwithstanding, other consultants acknowledge they have to steer the architect; otherwise an architectural vision will be expounded, with less recognition for MEP or structural engineering, which have to be taken into account in retrospect (De Jong, 2014).

Wieland (2015) explains how the strategic meetings made clear what the starting points were for all disciplines. This prevented that all disciplines start fighting for their own interest. In this case, it was decided that the architect’s vision was to be leading. Although everyone was allowed to issue criticism, hard constraints could not be debated anymore. Flamink (2014), on behalf of BAM PPP, also underlines the importance of the architect: in the schematic design phase you are bound to give leeway to the architect to develop and unfold his creative ideas; these will not develop from all the (partial) solutions by other disciplines. Based on the Strategy to Win, it would be best if the strategic team gives start to dialogue phase 1, and the disciplinary teams to 2 and 3. Strictly conducting the interdisciplinary collaboration might also be a impede full maturation of the design quality: as De Vaan (2014) mentions, a consortium that collaborates in a conducted pattern, and strictly follows the constraints given, will not win the competition. The design process must facilitate enough freedom, otherwise disciplines will not be able to use their abilities proficiently and the process will not be flexible to respond to (changing) client demand.

**Interdisciplinary Meetings**

These concern the meetings between project managers of the different disciplines. The goal was to evaluate the project work with respect to the integration of the different disciplines. Key findings were fed back to the strategic meetings. Wieland (2014) describes how all documents that have to be handed in with the client, are laid out beforehand: all disciplines know what documents have to be handed in for the BAFO. Dietz (2014) highlights that findings from disciplines come at a different point in the design process. Input is not given in a structured manner, but is brought to the table disorderedly. A design choice can win at the one moment on a certain disciplinary argument, but at a different moment an opposite disciplinary argument may win (Dietz, 2014).

De Vaan (2014) mentions that lean sessions, in order to link better the disciplinary works, only were introduced after competition win. It would be an improvement to initiate this in an earlier phase. For
the architect this would be a major constraint, because it forces him to deliver his design choices at a very early stage (De Vaan, 2014). However, time/detail structuring is needed to make this possible: Eekhof (2014) explains that M&O parties that issued questions regarding the detail design, when the architect was still shaping the main concept. Furthermore he mentions that the whole collaboration had an instant focus on the design. Consequently, all parties gave less attention to the exploitation phase. As such, Eekhof (2014) states that collaboration easily falls back to the traditional patterns/behaviour. Therefore, Eekhof concludes, it would be good if someone from the M&O side would attend the strategic design meetings, to express in the meetings what an abstract level is acceptable and what is not.

Arup claims that an improvement for the DBFMO competition would be if the M&O-side and the D&B-side brainstorm separately about the outcome that was the product of the strategic meetings. De Vaan (2014) asserts that the creativity of all parties would be enhanced if they can first give interpretation to the outcome, on the basis of their own discipline, without being constrained by others’. Parties should be appointed only a limited role, which they can work with from the perspective of their own specialised knowledge (Rutten, 2014). After brainstorming, the parties should present this to each other and on this basis choices should be made. Wieland (2014) believes that segmenting the disciplinary meetings would in a sense lead to returning to the traditional process: parties bearing the most financial risk, now have the chance to monitor project costs from beginning on. It points out that this would underestimate the influence of the contractor in the design phase (Wieland, 2014). In this project the structural design is strongly steered by aspects of knowledge and experience from the contractor. Dietz (2014), designates as an important disadvantage that in the DBFMO design competition the time is very limited, and therefore you are urged to already negotiate with the contractor and M&O-parties. Because of the limited competition period, it was regarded valuable that all parties were involved in the meetings (Dietz, 2014). Furthermore, Dietz (2014) claims that it would be an improvement to structure the meetings per subject. By doing this, the consortium could examen design choices directly with the requirements from the OS. This could have been done better in the Hoge Raad: many decisions were taken intuitively and therefore some requirements were overlooked (Dietz, 2014). Kok (2015) asserts that the interdisciplinary meetings were not optimal: they were often organised by the EPC, and brought only EPC design issues to the table. For MTC parties, only 20% of the discusion was relevant, but they have to be assessed completely, because it cannot be determined beforehand which topics become important for the MTC beforehand.

B.5.4 Interdisciplinary analyses

Results Project Documentation study & Interviews

Collaboration in a DBFMO design competition is explored by means of researching how interdisciplinary analyses have been carried out. The consortium internally divides tasks, undertakes analyses and shares results in detail.

Who does what? ...

From the 14 meetings that were held on 2/3-weekly basis, 55 distinct analyses were discovered. Consequently, a table was compiled, setting out the different characteristics of all analyses. This table can be found back in Appendix B. The analyses, categorised per DBFMO term, Domains, Request for Information and Analysis Method & Unit of analysis are projected on a timeline. The example is shown in figure 7, a larger format of the scheme can be found in Appendix AB_2. The results are projected on the interval between 1st interdisciplinary meeting and BAFO. First, it can be seen that many red (=Build) and green (=BM/M/MO/O) analyses are addressed at the very beginning, whereas more analyses in blue (=design) are executed in later phases. It can also be seen that there is a gap between B05 and B06 (B0=interdisciplinary meeting). In this period, from 7-12-11 until 16-2-12, no interdisciplinary meetings were held.

...on which moment? ...

From the recurrence of analyses as a topic in the interdisciplinary meetings, we could make assumptions as to when certain activities took place and when they were finished. Although these are drafty assumptions, they gives an indication if there is any linkage between certain analyses: either they started at the same point, followed consecutively or there was simply no correlation. The results of this research were mapped out in a second table, that elaborates on appendix AB_1, adding a second row for the finish date of the individual analyses. There is also added a second scheme as a product of this, showing the duration of the analyses on the timeline, can be found in appendix AB_3.

...on which detail level? ...

To explore the detail level, it first is distinguished which particular analyses applied to the specific building parts (i.e. Open transparent façade, comfortable workspaces). Assumed linkages (i.e. follow-ups and feedback loops) are added, on basis of own assumptions.

Strategy

The detail level on which the project documentation proceeded was crucial for enabling successful interdisciplinary collaboration. Wieland (2014) names that a certain detail level is required to assess the feasibility of a building element/technique/structure. In this case of an early design phase, the parties are
required to already go into detail on some aspects, and to give input for other disciplines to start feasibility analyses. If some aspects on a detailed level prove too problematic, the design returns to a lower detail level to look for alternatives (Wieland, 2014). In this way, the detail level is used to fast-forward on some aspects to quickly research the effects on deeper layers (e.g. maintenance and operability). Eekhof (2014) explicates how facility management is used to react to details: “Our business is a manual work-business: it needs to be explained how long it will take to clean a single facade tile. If one can save a few minutes per tile, this effects maintenance works 4x a year, for 30 years.” Levels of detail were also necessary for the M&O-side to side to perform life-cycle analyses. By calculating the impact of certain choices, alternatives could be set up (Eekhof, 2014). This also resulted in deciding on investment costs and operational costs (Eekhof, 2014). In another way, the architect also used levels of detail carefully, to acclaim architectural/aesthetic goals: architectural design choices (following from analyses for the column-free facade, and multifunctional aesthetic climate ceilings) were developed on a high detail level very early on. By doing this, other disciplines now were pointed in a direction, to focus on looking after life-cycle of particular aspects. By doing this, in an early phase a solid basis of knowledge is gained, tailored to the specific demands of the client (and thus winning the tender).

Vos (2014) explicates that the architect had to develop the design on the cutting-edge straight away to fit in all OS requirements. This constrained the other parties in design possibilities. Besides, a higher detail level was demanded at an earlier stage, e.g. for free clearance height/climate installations. Disciplines might have preferred to develop this at a later stage, Vos (2014) concludes.

**Example strategic flow: Column-Free Facade**

One of the strategic flows of the design was the column-free facade. This example illustrates again how different requirements pertain to design choices that are seemingly very distinct: the free clearance height for the ground floor, which was of key importance for the design quality, resulted in a higher building, which threatened to conflict with the urban building envelope. Moreover, allowing for such a great span in the column-free facade, needed for a large structure on the second floor. Dietz (2014) admits that when looking at the amount of steel used on the 2nd floor, one would ask himself if this could have been done more cost efficient. On a different level, a strong ambition of the architect was backed-up with technical detail drawings at an early stage. De Jong (2014) defines that the façade design was crucial for dialogue product 1: it influenced choices in regard to sustainability, climate and comfort drastically.

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**Figure 8 facade analyses influencing other domains in strategic flow (Graph by Author)**
**Detailing to Client Demand**

Obviously, levels of detail were in the first place determined by what was demanded by the client as output for the dialogue products. Eekhof (2014) explicates how it needs to be researched to make the design more efficient or smarter, without having impact on the quality for the client. “If you have designed something and proposed to the client, and you later deviate from this, you will loose your client.” (Eekhof, 2014)

Flamink (2014) denotes the importance of knowing in which phase certain design issues (and discounts from the rebate mechanism) can be controlled. From the rebate mechanism the risk-concerning issues were underlined, scenarios were established, and were presented to the disciplines (Eekhof, 2014). This determined the type of analysis and the detail level. Vos (2014) explicates: at some point we had to come up with a cost calculation – then immediately many maintenance issues are brought to the table. Budgets are determined using indicators. Wieland (2014) explains how BAM-U used these to decide on life-cycle costing: indicators were used to decide on certain design aspects, mainly on product choices. For instance, for the floor finishing it had to be decided between carpet and natural stone flooring. Wieland (2014) explains how it was experimented with choice matrices using LCC calculation:

unexpectedly, from the matrix it was concluded that carpet tiles were more economical than natural stone – a single stain on the stone, could require the whole corridor to be cleaned, Wieland (2014) concludes. Although the design process seems very structured, structuring was a very difficult task. Dietz (2014) explicates that parties constantly were constantly questioning themselves as to the level of detail analyses had to be run at. Parties were bound to go very deep into detail to just be assure of design choices. “One goes further than what is expected of him – you do extra research in a phase, just to be sure to win.” (Dietz, 2014).

**Programming the Detail level**

From above mentioned, the question arises if this structuring of the detail level can be programmed. Dietz (2014) contradicts this by saying that the transcription of the OS/award criteria to the specific design ambitions in architectural detail (e.g. column-free facade) is ill-defined and not programmable. “It is an intuitive matter”, Dietz (2014) explains. The process of transcribing criteria to design options using imagination and picking the right analyses to test the options cannot be planned. “This is the quality of the architect”, Dietz (2014) arguments. However, patterns can be established for the transcription of common principles to key details.

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![Figure 9 Scheme Hoge Raad Categorised Analyses on Timeline (Graph by Author)](image-url)
Analyses now emerged ‘randomly’ in the process, when there was a need. Notenboom (2014) asserts that the importance is not to know where exactly certain analyses take place, but it does help to know certain links between analyses/activities if one is not acquainted with the route of thinking. It could be planned somehow, with certain logic, but in reality analysing and decision-making is simpler and more intuitive (Notenboom, 2014).

Eekhof (2014) describes the efforts to structure the detail level by means of a standard programme of requirements: this describes which spatial requirements were needed, and what the effect is on the design (Eekhof, 2014). However, if you want to get full comprehension, you also have to look at the finishing materials in an early stage of the design process, which is not interesting at that moment (Eekhof, 2014). Efforts to structure detail levels have emerged by the use of BIM software. It can be asserted that by using BIM software, levels of detail can be stipulated to a certain extent. Although the Hoge Raad as the first DBFMO project imposed a complete undertaking in BIM software after competition-win, during the competition disciplines were allowed to use any means to analyse. Wieland (2014) argues that if BIM was imposed in the competition, the threat is that disciplines would go into detail too much. “I would be worrying about the choice between stainless and normal steel screws” Wieland (2014) says. He explains that if one would use BIM for analyses, this would imply that the first BIM design model should be constantly updated, in order to address analysis inquiries at some point during the design process. Therefore he concludes that using BIM in the competition is not efficient. Eekhof (2014) did find the BIM model useful: it provided us with 1. the opportunity to see all minor room edges for cleaning and 2. It delivered us concrete area numbers. This made possible for us to better oversee the life-cycle costs. It was possible to base our calculations on this, and also to see the functionality of the building (Eekhof, 2014).

**B.6 Margins for Interdisciplinary Collaboration: Client Demand & Competition**

**B.6.1 Client Demand**

There is a fundamental difference between a DBFMO and a traditional project. In traditional projects, the client has to settle its requirements so that the designing parties can carry out certain design activities. In a DBFMO the commissioner has many power over the design, due to the competitive dialogue the client can adapt its wishes and requirements along the design competition (De Vaan, 2014). Eekhof (2014) mentions how in the beginning of the competition, the ambition level of the client can be read from the award criteria. These are analyses per discipline, offering (1) An interpretation of the client ambition and (2) An indication of the cost drivers per discipline. If these are well controlled, services can be performed efficiently and at a satisfactory price (Eekhof, 2014). Wieland (2014) further holds that all design choices are thus related directly to what the client wants; therefore the wishes of the client have to be anticipated. However, establishing a standard for this would be difficult: there are peaks and troughs in the demand, and additional points of attention (of both client and consortium) develop along the way. It would be difficult to settle a design process in a single principle and develop it always according to this principle (Wieland, 2014).

De Jong (2014) discusses the importance of knowing on which criteria award points can be won per phase. In this project, aesthetics was the most important award criterion. De Vaan (2014) names the importance of knowing your client during the competitive dialogue meetings. This is particularly difficult, because there is not one client, but more, and these have a variety of wishes and concerns. “Who do we really need to convince? Who has the power?” (De Vaan, 2014). Flamink (2014) names that learning to know the demands from the Chief Government Architect and the president of the Supreme Court was paramount during the competitive dialogue. The competitive dialogue meetings are formal meetings: the client clearly structured the progress of this meetings, making sure that not more information is given to the consortium than necessary: the client did not really provide with information, because of the competitive nature they could not give an advantage to one party over another (Vos, 2014). Clients act as accountants: they control every minor detail, because they are audited by the National State Audit Office (Flamink, 2014). Therefore, consortiums strive to retrieve as much information as possible from the dialogue meetings. Wieland (2014) upholds that the information from the dialogue meetings should be better find its way into the interdisciplinary meeting and strategic meetings. Much information is lost at this point, which is unfortunate, because analyses can be tailored to this feedback.

**B.6.2 Project Output**

For the project output, the consortium bid strategy was paramount (Flamink, 2014): in dialogue phase 1, the complete budget was spent on the design; “later we lowered our tender offer for an economically most attractive tender (EMAT)”. Kok (2015) explains that lowering the tender offer is a strategy one chooses purposely as a consortium; one could also choose to comply with the minimum requirements for a minimal offer. In that case, the price strategy is to start really bare, instead of starting bold and consecutively undressing the offer. Notenboom (2015) adds that in case of the Hoge Raad, the chosen strategy to start at
the highest tender offer was important for preselection in dialogue phase 1. Depending on the ruleset, it is crucial to deliver a design that overwhelms your client. “This also means you created qualitative expectations, you cannot deteriorate on your offer anymore.” (Notenboom, 2015). Eekhof (2014) mentions how output differs in relation to the importance of the M&O side in the project. In other projects driven by an M&O-demand, with hard requirements for M&O and constructability, one would see a functionally and structurally sound design, but lacking not aesthetics and comfort. In such projects, the structural engineer had laid down such hard requirements, from which could not be deviated, that some design solutions had to let go off (Eekhof, 2014).

The weighting in the tender (D&B) differs from the weighting in the turnover (M&O). Kok explains how more weight is given to winning in the tender phase: in the D&B phase there are a number of terms that individually have their risks and costs (Kok, 2014). However, after establishing a price, which is issued as the Best and Final Offer (BAFO), this cannot be changed; it is the price you will be remunerated for. Therefore, the Special Purpose Company (SPC) that is set up for the project finance, will sharply control the BAFO price. Scenarios are developed, in which the offer is checked for the feasibility of delivering the offer for the given price. Banks and investors will also challenge you with sceptical questions about the offer: risks cannot be overseen or underestimated; otherwise problems will arise (Kok, 2014). Cost calculations are plotted versus quality levels: scenarios are calculated and it is assessed on which level of quality with the correlated costs, the consortium thinks it is a winning project (Notenboom, 2014). This then has to be defended with the board of executives. The investments in such projects, Notenboom (2014) explains, are of such scale, that DBFMO projects need a certain volume and risk profile to be interesting. Small projects in a DBFMO contract are not interesting.

Interdisciplinary analyses in the design competition aim to give an answer to the question if the design can be delivered for the given price in an offer to the client. Answering to the rebate mechanism is key in this regard. In this document, the client has described what he will deduct from the fee, if certain services in the building do not work (sufficiently). Analyses for checking compliance with the rebate mechanism has room for improvement, according to De Vaan (2014). Rutten (2014) adds to this that this was done long after a variant was chosen, and this would then be simply approved or disapproved. It would be better to account for aspects of the rebate mechanism in the variants analysis already. Rutten explains that the costs are determined at a stage that can be considered too late, and not on a detail level that is in accordance with the variants analysis. It would be an improvement to involve the cost calculator in an earlier phase, who can calculate the (initial and operational) costs on a general outline. In addition to this, Flamink (2014) underlines the importance of making insightful that the capital expenditures that the design brings about, do have to fit with what will be actually build, in order to receive money from the creditors (banks) (Flamink, 2014). He adds that analyses thus have to deliver design options that can be procured and constructed.

B.7 Discussion

B.7.1 Positions in Interdisciplinary Collaboration: Consortium Establishment

How to share knowledge between disciplines?

By virtue of good disciplinary knowledge sharing, disciplinary analyses can build on each other. Project documentation shows that for almost all domains, using information from the generic analyses information was fed into an integral discipline plan or a ambition document/focal points. In the strategic meetings the higher management of the consortium parties decided to fast-forward on some ‘flows’, to see in detail how certain design choices, designed on basis of key OS/award criteria, would work out on a higher detail level. The choice of working in the design process from broad to fine recurs in the DBFMO; this is not different than in the traditional process. The detail level is ill-defined: it differs per system and can vary per discipline per phase. Dietz (2014) explicates how in the project there was a constant struggle in linking detailiness of models, with phases and disciplines. Programmability thus should not be seen on the level of concrete task breakdowns, but on the level of global processes. The link between (project-specific) analyses, and phases, disciplines cannot reasonably be fixed beforehand.

Disassemble or assemble DBFMO elements?

In the Hoge Raad project, many interdisciplinary analyses still refer to design and build aspects. This can be explained by the award criteria, that were more directed at design quality. It is apparent that in the Hoge Raad aspects affecting the maintainability of a building, often also are related to the constructability or operability. Interviews confirm that there is a direct urge of the D&B parties to know what the consequences of their designs are: there is a steady line between the requirements from the OS/award criteria and the design delivered, but these need to be integrated with the M&O wishes. The study of project documentation shows that analyses affecting B/BM/M/NO aspects cluster in the very beginning and analyses only affecting design aspects appear later (around dialogue product 3). Issuing build, maintain and operability questions in the very beginning of the design process might lead to congestion of the chain of analysis. It leads to more work done at a higher
detail level very early in the project, but it can be questioned if all the analyses have proven to be useful. Due to absence of an overview all stakeholders urge to have their risks analysed very early, but these risks are researched individually and not in relation to one another; this could be improved by structuring the information better.

B.7.2 Relations in Interdisciplinary Collaboration: Integrating Disciplinary Views

How to Control the DBFMO process?
Strategic flows guideline the creative process in the competition. From the full spectrum of the output specification and award criteria, focal points were chosen and these were forwarded to the disciplines. They, on their turn, research these aspects into depth, on the full time-scale of the DBFMO. It can be seen that only on a small margin of the full spectrum of design possibilities research was done, and the aspects within this margin were scrutinised thoroughly in all DBFMO terms.

Project documentation study shows how for these strategic flows, analyses relating to maintenance and operability of the building cluster in the beginning. From the early beginning on, strategic flows as being award-winning or crucial for the design, press to have all relating analyses researched to identify its feasibility. Although this being very determinative, there was no structure for addressing the specific aspects according to a time path. A strong emphasis on the quality of the architectural design was key in this collaboration; in order to acclaim their goals, the architect actively stood ground opposed to the disciplines. This presents the hierarchy and muscle-showing that stakeholders use control to the DBFMO process. It can first be questioned, whether such power-play endorses collaboration, and secondly, if it is advantageous. That is to say, if it can be programmed/anticipated. As Flamink (2014) asserts, it might be advantageous if the initiative changes per phase from strategic team to disciplines and vice versa. However, conducting collaboration patterns may be dangerous: as De Vaan (2014) mentions, a consortium that collaborates in a conducted pattern and strictly follows the constraints given, will not win the competition. The design process requires enough freedom, otherwise disciplines will not be able to use their abilities proficiently and the process will not be able to flexibly respond to (changing) client demand.

In regard to the programmability of the DBFMO process, consortium parties believe that flows can ‘somehow’ be anticipated in relation to DBFMOs in general, but the exact subject of the matter is not foreseeable. Arup asserts that the DBFMO terms could be structured better by first letting the D&B respectively M&O discuss separately before presenting to each other. The contractor challenges this: knowledge from the contractor and M&O parties is crucial in the early design phase. The architect claims that an improvement would be to structure the meetings per subject and to directly examine design choices with requirements from the OS. When comparing both options, the choice for structuring meetings per subject instead of separating parties seems more logical in the line of thought of the DBFMO. The added value of the DBFMO construct is that parties are able to use each other’s knowledge on different DBFMO terms along the design process, and thus this option should be investigated more thoroughly.

Integration of phases
By making use of the DBFMO construct, there is room to transform a ‘design issue’ that appeals to e.g. a design party into a ‘design opportunities’ for e.g. a maintenance party, through connecting these with other over the timeline. Disciplines possibly affect other disciplines at the same moment, but might also affect others over time (different phases). As Wieland (2014) asserts, the right disciplinary question has to be distilled from the ‘broad’ design question, and has to be put into terms that are easiest to comprehend by the undertaking discipline. Parties gradually learn how to formulate their inquiries in terms of the other disciplines. In interdisciplinary meetings, negotiations serve as collaborative ‘analyses’, and this proved in the interviews more common than appointing single analyses to disciplines (Dietz, 2014).

Integration of parties
Using the variety of parties involved, disciplines can look for other disciplines to undertake design analyses, or can be requested by others to undertake interdisciplinary analyses. The case study showed that most requests were addressed to Kaan and DGMR. These requests regard security (O) & fire safety (B) on the one hand and regard acoustics & lighting (D) on the other. The first cover ‘abstract’ yet influential aspects, and the latter cover questions that are ‘detailed’ yet less influential aspects. Interdisciplinary analyses collaboratively done by Kaan and Arup fall in between those of Kaan & DGMR. It gives room for Kaan & Arup to start developing an integral architectural design on basis of the structural and MEP design. Lastly, analyses in which BAM-T as an addressee is involved, cover planning and integrated procurement issues, and safeguard compliance with sustainability specifications from the client’s OS.

B.7.3 Margins for Interdisciplinary Collaboration: Client Demand & Competition

How to read a dynamic client ambition?
A dynamic client ambition (on basis of Hoezen&Doree, 2008) is reflected in changes in client specification. The interviewees underlined that the power of the client in the public commissioned
DBFMOs: During the competitive dialogues the client sharpens its demand without giving any feedback on what is designed. D&B parties are not used to this. Although the client’s wish is expressed latently, the results of the dialogue are not fed back to the design team optimally.

Also the contemplation of the analysis rebate mechanism accounts for the client ambition: considerations between design variants need to be tested in this regard. Project documentation shows that ISS (almost) exclusively requests the consortium to check for compliance with regulation and to foresee on how this compliance will reflect in the rebate mechanism. This initiates a multiplicity of analyses that are ignited from the very beginning of the competition. Consequently, costs were determined in at a stage that can be considered too late, and not on a sufficient detail level. The rebate mechanism constitutes a minimum requirement for the building’s performance. Interviewees argue that BIM might help in making insightful the design to the client by which the client’s direct feedback on the model could be interpreted better.

**How to address to a dynamic project output?**

A dynamic project output (costs) (on basis of Smorenberg et al., 2007) result in consortiums to sharply price their project bid, using a budget that balances a building full-compliant with client OS and award criteria, constructability, maintain & operability and financability. The dynamic project output results in practice for project financing in two structures that generally account for capital expenditures (EPC) and operational expenditures (MTC). Project documentation points at the fact that M&O parties urge to know what the effects of the design are for services after completion: numerous M&O requests were addressed by ISS in the beginning. After the architect has finished the dialogue product 1 (concept design), the M&O parties directly urge to know what the effects of this design are for the services after completion. During the exploitation period the costs and replacement moments are a direct result from choices made in the design phase. Dietz (2014) mentions how designing parties would easily overlook M&O requirements. On the contrary, M&O parties are not used to deliver their input with the D&B parties from the very beginning (De Jong, 2014).

**8.8 Conclusions**

**Research subquestion B**

Where does complexity manifest in the practice of interdisciplinary collaboration in a Dutch public tender DBFMO design competitions?

**Positions in Interdisciplinary Collaboration**

- The project is becoming more complex due to the linking of M&O aspects to the design process: M&O parties were not yet used to delivering input from the very beginning, and D&B parties were not used to involve M&O aspects. However, it is crucial that M&O aspects are monitored during the design. This demands not only for actively involving M&O parties in the beginning, but also for them to directly steer D&B parties.

- Requirements from follow-up phases that affect initial versus operational costs increase the complexity: risks of design issues cannot be located with a single discipline, nor risks can be categorised within a single DBFMO term. Although depending on the OS and award criteria it has to be assessed what the weight of M&O services is for the project value.

**Relations in Interdisciplinary Collaboration**

- The anticipating of other disciplinary works for strategic flows increases complexity in the DBFMO competition: High-level management, after studying the OS/award criteria chooses for strategic flows, to fast-forward on the consequences of crucial (award-winning) design.
decisions later. Although crucial for the design, these top-down decisions were insufficiently controlled by a scope of work that could be controlled during the project. Disciplines would be better able to anticipate each other’s analyses and other design activities if these were better structured, and controlled.

- The integration of parties raises the complexity of collaboration because the DBFMO contract directs accounting for all issues that might occur to stakeholders along the contract period. Parties must see what the requirements of others over time are, before they can fit in to help others to undertake analyses when they are in a mature phase.

- Complexity is raised by the efforts in interdisciplinary collaboration, to not have all analyses congest at this moment. The high importance of strategic flows urges stakeholders to press to have all relating design issues researched at the very beginning. Design choices now were prioritised due to hierarchy and power-play of disciplines. Programming the prioritisation of the design choices demands for an anticipation of all interfaces in the project.

Margins of Interdisciplinary Collaboration

- Complexity is found in the way client demand is interpreted and fed in into the design process. Parties have to adapt to strict rules of the competition, in which a changing client demand requires a proficient interpretation in order to appoint disciplines to work. In addition, the rebate mechanism adds to complexity: the research concludes that insufficiencies in addressing the rebate mechanism is due to the parties not being used to deliver a performance instead of a commodity.

- The contractual constructs of EPC and MTC demand for different accounting of expenses. D&B and M&O parties must get better acquainted to each others demands/supplies. In addition, It would be an improvement if building element’s quality (in both D&B and M&O aspects) can be argued in similar terms for CAPEX/OPEX.

In summary

The case study shows that a sectional interest makes the positions in interdisciplinary collaboration more complex:

- Both D&B and M&O parties are not used to linking of M&O aspects to a design project.

Lastly, the case study presents that a disparity between competition and collaboration makes accounting for margins of interdisciplinary collaboration more complex:

- A changing client demand and rebate mechanism are insufficiently interpreted and can be explained by parties not being used to a service-led contract.

- Different accounting systems for the expenses leads to ignorance between EPC and MTC in understanding each other’s demands/supplies.

B.9 Limitations

- Single-case research: the interview sample size is limited. A small number of participants can be questioned. Due to this small sample size, it is arguable if results can be generalised. Although the results can give a clear indication, other consortiums/subcontractors in the industry may act differently due to company specific behaviour.

- Collection of data: the measure used may be biased. This might be due to the theoretical preparation for the interview. A wealth of experience might have resulted in different questions. In addition to the methodological limitation, there are also longitudinal effects. The time available to investigate this research problem is constraint by due dates and interviewee’s availability. Therefore, it is difficult to conduct a full coverage of theory and conduct multiple interviews.
PART I

COMPLEXITY OF CURRENT DBFMO COMPETITIONS

C.

COMPLEXITY OF CURRENT INTERDISCIPLINARY COLLABORATION IN DBFMO COMPETITIONS

“Exploitation revenue outweighs tender value - Yet, numbers fade away as to the testosterone that flows; alpha males dominate the wolfpack. It seems primitive, but it is the way it goes.”

(Kok, 2014)
C. Complexity of Current Interdisciplinary Collaboration in DBFMO Competitions

C.1 Introduction

SQ.C What is the explanation for perceived complexity of interdisciplinary collaboration in Dutch public tender design competitions?

In the previous chapters the theoretical context and complexity in practice of interdisciplinary collaboration in a DBFMO design competition has been described. The conclusions of both literature and case study direct at three phenomena that appear in the context of DBFMO, but can be traced back to habits rooted deeply in collaboration (in the construction industry). This chapter has the following outline:

C.2 Complexity in context
C.3 Complexity in positions: locked in sectional interests
C.4 Complexity in relations: network vs. hierarchy
C.5 Complexity in margins: caught between competition and collaboration
C.6 Discussion
C.7 Conclusion

This chapter gives an explanation of perceived complexity in interdisciplinary collaboration in a DBFMO design competition. The exact character of the complexity, and its underlying reasons will be touched upon. First, this research lays out the interpretation of complexity in interdisciplinary collaboration (C.2.1) and in (DBFMO) design competitions (C.2.2). In the discussion (C.2.3), this paragraph explains what the research aim is for the consecutive paragraphs. Using literature, explanations from known academic research are induced, for constructing roles and instruments to optimise interdisciplinary collaboration in chapter D.

C.2 Complexity in the context

C.2.1 What is the complexity of interdisciplinary collaboration?

In project management literature complexity is explained as the divide between complicated and complex (Baccarini, 1996). Complicated indicates to the numerous elements that a project combines and are interrelated, and complex specifies the unpredictability of this relation. Therefore, Baccarini (1996) asserts that complex projects are regarded as being complicated and complex at the same time.

Bektas (2013) specifies relations between different aspects in large complex building projects, and makes the distinction between:

- methodological (tools, approaches, perceptions and technologies)
- institutional (organisational, contractual, political)
- programmatic (requirements, building systems)

Bektas (2013) continues by saying that in the different phases of a large complex building’s life-cycle, a large number of different organisations commit to the projects with their disciplinary knowledge. She refers to methodological complexity, in the manner by which different disciplines compose a technically and socially complex product, which integrates a multi-faceted knowledge. Jones and Lichtenstein (2008) direct to institutional complexity: they claim that integrated projects are complex due to the demands for multiple organisations’ involvement, and the constant interaction, which consecutively introduces challenges for inter-organisational coordination. Other scholars see this in a different light: Floricel and Miller (2001) draw the attention to integrated building projects that carry a higher level of programmatic complexity, for the unpredictable nature of the interdisciplinary design process cannot be overseen.

C.2.2 What is complexity in the context of a (DBFMO) design competition?

Bektas (2013) highlights that a clear interpretation of complexity in the context of design competitions is still missing. However, scholars agree that design competitions are incrementally becoming more comprehensive, the quality demands are intensifying, time pressure is growing, public expenses are monitored more precisely, and it is becoming to a greater extent more difficult to expect a possible solution to a problem issue (Alderman, Ivory, McLoughlin, & Vaughan, 2005; Williams, 1999). Other interpretations of elevated project complexity are: a changing government role (Blanken, 2008), and the changed tasks and roles of the market and of the government. Bajari, McMillan, and Tadelis (2009) describe that from these changes in tasks and roles, commitments and negotiations between public commissioners and contractors are continuously changing.

Other sides to this complexity are also named: (ElMaraghy, ElMaraghy, Tomiya, & Monostori, 2012) mention that the competition and forced cooperation constraints inhibit the development of a party’s flexibility in strategic behavior. In the contemporary competitive environment, strategic flexibility is contemplated as an advantage (ElMaraghy et al., 2012).
C.2.3 Discussion

The division in complexity introduced by Bektas (2013) (i.e. institutional, programmatic and methodological) presents similarities with the division made in this thesis (position, relations and margins). First, methodological complexity conveys the efforts to merge different disciplinary works (with its own tools, approaches, perceptions and technologies) to integrate multifaceted knowledge. This relates to the positions by which disciplinary interests, approaches, methods and paradigms are described in chapter A and B. Secondly, institutional complexity describes the relational constructs for making interdisciplinary collaboration possible; this relates to relations by which interdisciplinary activities are described. Lastly, programmatic complexity correspondingly to margins of interdisciplinary collaboration construes the boundaries that are established through the DBFMO design competition.

The complexity of design competitions described by Bektas (2013), Alderman et al. (2005), Williams (1999), Blanken (2008) and Bajari et al. (2009) give analog definitions of complexity as to the experienced problems concluded in chapter A and B. The assertion by ElMaraghy et al (2012) adds to the intention of this thesis research to strategically invent instruments to face the complexity of DBFMO design competitions.

Using the interpretation of complexity in literature from this paragraph, and using the researcher’s own interpretation of perceived phenomena in chapter A and B, in the following paragraphs an explanation (from literature) to own perceptions of complexity in interdisciplinary collaboration in a (Dutch public tender) DBFMO design competition will be given.

C.3 Complexity in Positions: Locked in Sectional Interests

Interdisciplinary collaboration in DBFMO projects demands for an aggregation of different disciplinary views in a single consortium (occasional collective). These disciplines have diverging backgrounds, knowledge, methods, ways of thinking etc. and thus need to learn to cooperate in a different way than in the traditional process, e.g. the maintenance & operate parties were not used to give input at the beginning of the competition. This was explained by the fact that they as M&O parties were not used to bring in their competencies at such an early stage. Organised collaboration between disciplines during the competition is strongly influenced by the contractual constructs of the EPC and MTC that come into being after competition win. Differences in interests appear for the EPC the DBFMO is foreseeable short-term project, whereas for the MTC the project becomes more a long-term process, in which new stakeholders join in and leave. It can be seen that sectional interests, in aligning the different participating parties in a consortium. This behaviour is in similar way described by Lerdahl (2001) in his doctoral thesis ‘Staging for Creative Collaboration in Design Teams’

C.3.1 Literature on Sectional Interests

As Lerdahl (2001) describes, in multidisciplinary team collaboration a main problem is that disciplines become stuck in sectional interests and loose their holistic perspective. Each participant is merely thinking about its own area of interest. This seems to be partly due to the fact that the different participants come from different cultures. There is also a lack of awareness around changing of roles in the integrated team. Furthermore, the different participants are fixated on the area they traditionally are evaluated on. Furthermore, Lerdal (2001) describes how sectional interests influence the positions within team collaboration, e.g. in meetings: ‘when participants get caught in discussions based on sectional interests it is hard to get out of discussion, because no one wants to feel as a loser’. Therefore, it is crucial that the group acts more cleverly in developing a holistic view. The problem that arises when discussing holistic perspectives is that the perspective disciplines each have a different viewpoint on what should be considered holistic. Lerdal (2001) mentions the importance of developing a shared understanding before getting too much caught in individual sectional interests.

C.3.2 Importance of Shared Understanding

Bektas (2013) underlines the importance of disciplinary knowledge sharing in large complex building projects among design team actors. In these projects, design – by definition – represents a process in which actors solve a complex problem, and seek an outcome that requires multi-disciplinary knowledge to solve the problem. During design processes ‘new problems’ introduced in the work environment (with changing roles, responsibilities and the context in which knowledge is required), knowledge as a personal and intangible asset can be accumulated (Bektas, 2013). Lerdahl (2001) names that shared knowledge stimulates creative coupling; rigid role structure and too much sectional interest will give little creative coupling.

C.3.3 Creative Coupling

Zaccai (1998) describes creative coupling as a “fruitful bridging of knowledge and create a shared understanding”. He argues that a perspective changing of roles is central for collaboration and for innovation. He mentions that overlap adds new dimension and depth of knowledge to the role of each discipline. This overlap actually stimulates innovation and adds overall efficiency to the entire development process (Zaccai, 1998). Bastick (1982) adds that redundancy and overlap is an essential element for
intuitive thought. If different actors do not have the ability to take each other’s role and perspective it will be difficult to have creative coupling.

This lack of creative coupling is illustrated in figure 9.

![Figure 10 Proposed Correlation Between Creative Coupling and Role Structure (Lerdahl, 2001)](image)

In addition, it is equally important that the participants in a team feel secure about their own role. This means that the team does not end up in an unclear situation where everyone wants to do everything, but that the different disciplines in the team value the different expertise and roles in relation to the development project. It is proposed that a role structure that is too unclear will also lead to less creative coupling, see figure 4.

C.3.4 Conflict in Role Changing

Lerdahl (2011) studied the effects of role changing on conflicts in design teams by means of role-play exercises. In such exercises the members were asked to look upon and take the perspective of the other members in team meetings. The designer was asked to describe the perspective, worries, and challenges for the other participants in the team and vice versa. The study showed that such a simple exercise helped to loosen up the strong sectional interests and fixed roles. However, it is important that such an exercise is presented in a way that it does not reinforce polarity but on the contrary may help to create a shared understanding (Lerdahl, 2011).

Lerdahl (2011) describes how conflicts arise due to different impression and experiences of concepts. The responses from the participants to these exercises were very positive: they gave the feedback that such exercises made them increasingly aware of the potential conflicts in a company. Through such play they can learn to take a flexible attitude and not get so fixated in their usual roles. Kupferberg (1996) writes in relation to play: “The play forms a sort of free space in the human condition, a space where we can work on difficult problems and attain deeper comprehension through putting parenthesis around reality.” Nevertheless, playing with roles might also carry its own risks and even aggravate conflicts if it is not done in a proper manner.

C.3.5 How does sectional interest constrain in the competition?

A characteristic of the substance of design issues in a process design is the fact that they are dynamic (Schoorman, Mayer, & Davis, 2007). The problem changes in the course of time. The logical consequence is that the answer to the question whether something is a solution for a problem also changes in the course of time (De Bruijn & Ten Heuvelhof, 2010). On a strategic level, it has to be assessed what certain developments in client demand and technology might bring.

Further along the competition, several developments may now take place that call the defined environmental profile into question. Technological innovations may be found that drastically improve maintenance. However, the design has to be revolutionised. Trade-offs again have to be made and the whole plan consequently flips upside-down. This again brings ample work to all disciplines, and results in disciplines exceeding their honoraries. The dynamics of single disciplinary analyses may have a major impact on the way the design issue is approached on the whole. An intelligent problem solver will conclude that the problem lies not so much in identifying the most environmentally friendly product, but rather in determining how to sustain the process of continuous product improvement (De Bruijn & Ten Heuvelhof, 2010).

C.4 Complexity in Relations: Network vs. Hierarchy

As both literature and case study present, parties involved in the consortium are used to different ways of working: For design activities, parties are used to deliver their works in a hierarchy (sequential process), whereas for construction and exploitation activities on a bottom-up level in close (network) collaboration. There are two different organisational structures at stake in aligning the different participating parties in a consortium. This behaviour is in similar way described in process management literature.

C.4.1 Network vs. Hierarchy literature

De Bruijn & Ten Heuvelhof (2008) expound possible organisational structures into ‘networks’, ‘hierarchies’ and ‘hybrids’: First, a network can be defined as (1) a number of actors with (2) different goals and interests and (3) different resources, (4) who depend on each other for the realisation of their goals. This in particular pertains to consortiums in a DBFMO competition. Although goals and interest might align because of all being ‘part’ of the consortium, from the
individual positions of stakeholders (e.g. contractor taking high investment risk, architect/engineer low investment risk) one can conclude that their goals and interests might be accentuated differently. Secondly, hierarchy can be retraced in the formal organisational form of the consortium in a DBFMO design competition. De Bruijn & Ten Heuvelhof (2008) assert that generally many management models are based on the assumption that an organisation has a hierarchical structure and that decision-making processes take place in an orderly manner and in phases. For example, strategy building for a consortium: this is a phased strategy development. Opportunities and threats are mapped out, strengths and weaknesses are identified, a strategy is selected and then implemented.

Cooperation
Because of the different compositions of consortia, parties work in different positions with one another; as ‘complementator’ within the same consortium, and as ‘competitor’ when working in competing consortia (De Bruijn & Ten Heuvelhof, 2008). Because parties often times work parallel in different DBFMO competitions, a company may have a competitor that is a ‘complementator’ at the same time (De Bruijn & Ten Heuvelhof, 2008). One party might supply services or products in a complementary position that enhances the value of a company’s services or products in a competing position. This means that competing companies know that they are interdependent and so have to cooperate: co-operation.

Process Chain
Cooperation of different disciplines that have to compromise on long-term decisions (term of the DBFMO contract, e.g. 30 years) parallel in different DBFMO contracts will exhibit characteristics of a process, rather than a project. De Bruijn & Ten Heuvelhof (2008) explain that in a project a company takes a decision autonomously and subsequently defends it to external parties (Defend).x On the contrary, in a process a company takes a decision in consultation and negotiation with other parties (DDD: Dialogue, Decide, Deliver). These may be other companies that operate in the same chain, further downstream the lifecycle, which can strongly influence because of their position in the chain. Due to the different liaisons established in the DBFMO contracts, parties will learn about one another. These types of inter-firm cooperation also create interdependencies and strengthen the network-like environment of the party (De Bruijn & Ten Heuvelhof, 2008).

C.4.3 Hierarchy Characteristics

Uniform communication
The consortium has a formal structure in order to organise internal activities and to communicate with external parties. The formal structure of organisations is usually a hierarchical one (De Bruijn & Ten Heuvelhof, 2008). The reality may be completely different - organisation units have a great deal of autonomy, the top management has little insight into what happens in the capillaries of an organisation - but hierarchical authority can be used. However, in order to communicate with the client or external parties, one uniform voice is important.

Stability
A hierarchical structure is necessary to create stability in the consortium: in meetings, in order to address the different perspectives, goals and interests, there has to be a top-down conduct to foresee on mutual understanding to create uniformity. The greater the uniformity in or between organisations, the greater

As such, the DBFMO design competition can be seen as a hybrid organisation. Learning points a party gains about collaboration from the one consortium can be opportunified for use in a different consortium. In addition, at the same time a project has to be delivered, that has to meet sharp requirements. There are many stakeholders that have to confine to a long-term responsibility and major investments.

C.4.2 Network characteristics

External Network
In a DBFMO consortium, the participating parties do not only just establish liaisons with one another, but there is cooperation in a bigger frame: companies are also part of an external network; they depend on the support of external parties (De Bruijn & Ten Heuvelhof, 2008). Furthermore, for a party to be successful, it should serve not only the interests of the stakeholders within the consortium, but also those of the main shareholders of the company, whose interests might differ from those in the consortium.

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will be the *span of control* of an intervening actor (De Bruijn & Ten Heuvelhof, 2008). However, during the contract, in DBFMO collaboration, organisation units are added or removed, and mutual power relations will change, along with dynamics in the environment of these organisation units. Thus, this will result in a instability of the consortium.

**C.4.4 How does Network vs. Hierarchy Constrain the Competition?**

In the decision-making process of a DBFMO consortium, disciplines must realise that there is not a single problem perception; this only reflects the perspective of the actor concerned. The question is whether other actors have the same problem perception. Moreover, problem perception is dependent on the paradigm pertaining to the discipline. When there is a more or less objectivised problem, as in the case of project-based decision making, substantive analysis of this problem is imperative (De Bruijn & Ten Heuvelhof, 2008). When the focus is on problem perceptions, an analysis is of limited value. This causes attention to shift from substantive problem analysis to strategies to influence the problem perception of actors.

**C.5 Complexity of Margins: Caught between Competition and Collaboration**

The DBFMO design competition is strongly constrained by margins set by the *Rijksdienst voor het Bouwsheer* (output specification, terms, dialogues etc.) and the by the consecutive consortium appointed margins (strategy to win, budgets, etc.). Different internal organisational/meeting structures (hierarchies) are necessary to claim conduct over these margins. It thus can be seen that interdisciplinary collaboration within DBFMO design competitions is pressured by these margins. Hoezen (2012) describes this behaviour in her doctoral thesis *The Competitive Dialogue Procedure: Negotiations and Commitment in Inter-Organisational Construction Projects*.

**C.5.1 Client Position**

The combination of increased organisational complexity and changing government roles has changed the tasks and roles of the market and of government (Alderman et al., 2005; Baccarini, 1996; Bult-Spiering & Dewulf, 2008; Egan, 1998; Laufer, Denker, & Shenhar, 1996; National Audit Office, 2001; Walker, 2015). The public sector has less influence on the contents of works, and strive for “professional commissioning” with increasing outsourcing to market organisations. The public principal confines itself to monitoring and checking the public’s interest more and more (Hoezen, 2012).

**C.5.2 Margins set by the client**

The distrust between public principals and private contractors, resulting from the poor image and the culture of fighting over margins, has not been conducive to the handing over of responsibilities from government to market organisations (Blanken, 2006). Governments are becoming less involved in the contents of the work and more concerned with procurement, controlling the public interest, and monitoring the contractors’ activities. Rather than prescribing the input wanted from the contractors, the principal prescribes the output needed (product-led contract) or even the outcome needed (service-led contract) (Alderman et al., 2005). Technical knowledge is no longer the business of the public sector. Rather, the procurement and management of contracts with market organisations, and directing those organisations, has become the focus (Bult-Spiering & Dewulf, 2008).

**C.5.3 Communication between Client and Consortium**

Due to fair competition during the competitive dialogues, all open questions addressed are shared with all other competing consortiums (Sikkel, 2015). Sikkel (2015) explains how consortiums address the client open questions in order to mislead their competitors, and address closed questions to improve their own product. Hoezen (2012) underscores how parties involved in the design competition balance between open information sharing for an effective dialogue and keeping information to them because of competition procedure (Hoezen, 2012). Plainly, interdisciplinary collaboration as such is not optimal: there are a substantial number of aspects to improve such as the time and effort dialogues takes, the inclination to drift towards detailing and risk avoiding behaviour. (Hoezen & Dorée, 2008)

**C.5.4 Consortium Caught between Competition and Collaboration**

For consortiums it is not certain that external collaboration with the client or parties within the network will improve their chances in the competition. Openness about innovative ideas might even weaken their position (Hoezen, 2012). Due to fear that the client may cross contaminate ideas, consortiums struggle with decisions about what they should or should not discuss with the client. For the contractor, this leads to a certain tension between investment in the building of a relationship in search of a future partner and putting pressure in order to employ the competitive character of the competition procedure. For the client, there is the tension between being as open as possible to build on the relationship and holding back on information in fighting for the contract award (Hoezen, 2012). According to Hoezen (2012) innovation in interdisciplinary collaboration is restrained by cause of the competition framework. Since cherry picking is explicitly forbidden, a potential contractor’s attractive and innovative idea is unlikely to be executed if this not the Economically Most Advantageous Tender (EMAT).
C.6 Discussion

It can be seen that organising interdisciplinary collaboration requires a thorough understanding of the different backgrounds, knowledge, methods, ways of thinking of disciplines. Sectional interest is present due to traditional behaviour and to the contractual constructs that come into being after competition wins. This brings different views on future changes/adaptations of the building after completion: the MTC has a high stake in keeping the facility fit-for-purpose, whereas the EPC sees future changes as a source for extra income. Lerdahl (2001) names the importance of disciplinary knowledge sharing as a means to keep all parties involved and accountable of the holistic view. By organising shared knowledge, a shared understanding can create creative couplings between disciplines (Zaccai, 1998). On the contrary, the process needs to clearly delineate the individal roles of disciplines in order to make creative coupling possible. The solution to design issues changes in the course of time: future developments cannot be foreseen, and inventions during the design competition might revolutionise the design. Problem solving thus lies not so much in identifying the best solution at a particular point in the process, but how to sustain product improvement. From the traditional process, disciplines involved in the consortium are used to different ways of working: designing activities can be best followed in a top-down design process which is run through sequentially, whereas construction and M&O parties are used to do their activities on a bottom-up level in close (network) collaboration with subcontractors and suppliers.

As such, collaboration in a DBFMO consortium can be seen as working in a hybrid organisation. The interdisciplinary collaboration must allow for disciplines to follow a sequential (hierarchical) run-through of the process, though also leave open for disciplines to break this chain, for them to start design activities by exploring their network. The network characteristics of the DBFMO design competition are the external network, coopetition and a process chain. Within the hierarchy of the project conduct (i.e. uniform communication, stability), the consortium should embrace these network characteristics. However, someone from within the process must carefully monitor the external network, in relation to coopetition. Lastly, it can be seen that interdisciplinary collaboration is restrained by margins set by the client and the consecutive constraints set by the consortium. Interdisciplinary collaboration as such is pressurised, with increased outsourcing of activities by the client in a service-led contract (Alderman et al., 2005). Because of the client position regarding the principles of fair competition, consortiums involved in the design competition balance between open information sharing for an effective dialogue and keeping information to themselves because of competition procedure (Hoezen, 2012).

C.7 Conclusion

Research subquestion C

“What is the explanation for perceived complexity of interdisciplinary collaboration within Dutch public tender design competitions?”

- Due to sectional interest, traditional views on building processes endow differences in thinking of future changes/adaptations of the building. Moreover, the contractual constructs fence off an overall responsibility for the design. Therefore, disciplinary knowledge sharing is needed; a shared understanding can deliver creative coupling.

- Different ways of working result in a top-down respectively a bottom-up approach to the collaboration process. Collaboration in a DBFMO consortium can be seen as working in a hybrid organisation: a sequential (hierarchical) process forms the basis, from which can be deviated, for disciplines to start working in a network. By leaving open use of external network, coopetition and a process chain, within the hierarchy of the project conduct network characteristics can be opportuned.

- Interdisciplinary collaboration is externally pressurised by margins set out by the client and by the consortium itself. The increased outsourcing of activities by the client in a service-led contract that is awarded in a strictly regulated competition leads to imbalance in effective dialogue and keeping information in the consortium.
D.

CONDUCTING AN OPTIMISED INTERDISCIPLINARY COLLABORATION

“There is always friction, but in DBFMO interests and risks are mile-high. It is paramount that friction will not prevail. The secret is to isolate friction and to focus on the overall design direction.” (De Jong, 2015)
D. Conducting an Optimised Interdisciplinary Collaboration

D.1 Introduction

SQ.D What are the roles and instruments to optimise interdisciplinary collaboration to face the complexity of public tender DBFMO design competition?

Instruments
These consider the roles, directives, meeting structures and work scopes that are used in interdisciplinary collaboration.

This chapter describes roles and instruments to optimise interdisciplinary collaboration, designed on basis of the aggregation of principles (ch. A) and practice (ch. B), and it is reflected upon this by the phenomena explored in ch. C. These instruments offer an optimisation tailored for the Hoge Raad project, although they can be set as an example for other projects.

D.2 Scope
The scope compounds the improment proposal in respect to three aspects:

- focus only on the award winning subjects: these consider the (previously named) strategic flows, that account for a high interdisciplinary complexity. As in the actual Hoge Raad competition, the roles and instruments to optimise interdisciplinary collaboration do not account for the day-to-day design activities of disciplines. It is foreseen that these just follow the normal routine as in any other building construction project.
- Interdisciplinary collaboration after establishment of the design vision (after dialogue product 1). During dialogue phase 1 the consortium directors decide on the design vision, this is not taken into account.

D.3 Objectives
As mentioned in the recommendations for further research in the case study (B.9), it is chosen to focus in detail on the first two themes, namely organisation and meetings.

- Position: management role shift; roles based on levels in value chain instead of consortium companies
- Relation: create awareness for interfaces and discipline-crossing activities.

- Margins: make steps in the process explicit, in order to better convey how the competition constraints collaboration
- Instruments that work correctly, only are changed if room for substantive improvement is acknowledged in the case study.

D.4 Preconditions
Importantly, for the instruments introduced in this chapter, following preconditions are apprehended:

D.4.1 Current DBFMO Competitions
The DBFMO competition will be unchanged. Ergo, consortiums have to consent to the fact that improvement of competition conduct only lies within the possibilities they have at their disposal. The proposal considers the following:

- Three dialogue phases (dp1 = 5 competitors, dp2-3 = 3) and Best and Final Offer (BAFO)
- Communication with client goes via dialogue products and dialogues
- Competition bid has to be fully compliant with output specification
- Competition bid is selected on basis of award criteria using a scoring system

D.4.2 Role of the Client
The role of the client in the DBFMO competition is unchanged. This implies the following:

- The client gives no feedback from dialogues
- The client can increasing/change demands along the competition
- No responsibilities for the client regarding the project

D.5 Positions in Interdisciplinary Collaboration: Improved Management Roles
The issue of sectional interest is counteracted by making roles flexible: Roles now are divided on basis of different levels that serve the value chain (margins, relations and positions), instead of being divided on basis of disciplines. As such, the roles of the traditional Hoge Raad project management are slightly reordered, and a clear division is made between project managers (content) and process managers (collaboration). A single new role is introduced, i.e. the interdisciplinary collaboration manager.

D.5.1 Coordination Manager (margins)
The coordination manager in the new situation is the role of a person external to the individual business strategies of consortium parties, who can chair the coordination meetings. The role of ‘external examiner’ now is fulfilled by the SPC, but in this new situation can be fulfilled by any knowledgeable person, able to overview over all issues. The key characteristics for this new role are:
D.5.2 Interdisciplinary Collaboration Manager (relations)
The interdisciplinary collaboration manager is a new role introduced to the project. The IC manager is an external process manager, who balances the design goals and strivings of all parties in the process. The key characteristics for this new role are:

<table>
<thead>
<tr>
<th>Role</th>
<th>Task</th>
<th>custody</th>
</tr>
</thead>
<tbody>
<tr>
<td>role external/independent from the design process: the IC manager is a person external to the consortium parties. This person can be objective in regard to possible conflicting views between party and consortium.</td>
<td>Task to appoint custodians on basis of work packages: it is the task of the interdisciplinary collaboration manager to appoint custodians, and control them. The interdisciplinary collaboration manager’s task is to oversee on e.g. Custodians from an architectural discipline, but are involve with MEP issues, should confine them to the role of facilitating the work scope.</td>
<td>Safeguard the integrity of interdisciplinary collaboration in relation to design vision: the interdisciplinary collaboration manager sees on how disciplinary works can add to one another and to how all works help to establish the chosen vision. However, role responsibilities should be left with the different disciplines.</td>
</tr>
<tr>
<td>participation in: all meetings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
D.6 Relations in Interdisciplinary Collaboration: Improved Competition Value Chain

In the set-up of delivering the improved competition tender, certain new terms are introduced. On basis of the procedure followed, the terms can be placed in a value chain (figure 10). Below only new terms are denominated.

D.6.1 Work scope

*Strategic flows* are formalised in a workflow that describes the linkages and interactions between work packages. Work scopes are established for design choices that are anticipated to be award-winning or need special attention, and are controlled by the custodian throughout the competition.

- Custodians are responsible to draft a work scope for the strategic flow. A work scope comprises different work packages that are linked in a chain that works from coarse to fine. Work scopes convey different domains in which work packages have to be carried out in order to deliver a complete design.
- For the establishment of work scopes, the EPC and MTC manager check separately, to assess the feasibility of the work scope. After evaluation, in the interdisciplinary meetings both parties should present this and after reflecting on the strategic choices, these are fixed.

D.6.2 Work packages

The concern analyses and other design activities that are strongly interrelated bundled together.

In a DBFMO design competition the goal is to aggregate the forces of all involved parties optimally. Ergo, parties should be given space to perform their work in the way they are used to: it is important that the contractor has the opportunity to explore his work package in relation to other activities. Therefore, the work scope gives room for the discipline to explore different solutions for work packages in relation to:

1. Other work packages in the project
2. Other work scopes in the project
3. Other project
4. Other activities within the party’s own network

**Interdisciplinary Process Diagram**

The process tree (figure 11, enlarged App. B) outlines in general terms how the *value chain* is controlled by different roles. Moreover, it shows how extra input is given to ensure adherence of MTC requirements (MTC Directives, D.5.1), work scopes are set up (D.6.1) and it shows what steps are taken during the different meeting types (D.6.4). Therefore, the proposed schemes describe steps that provide parties with clarification of when certain design decisions will be taken.

![Interdisciplinary Collaboration Process for Delivering Value Chain (Graph by Author)](image-url)
D.6.4 Meetings

**Coordination Meetings (related to table 10)**
- Coordination meetings are chaired by the coordination manager, and are attended by: interdisciplinary collaboration manager
- Discussion on how strategy 2 win can serve the project definition
- Discussion on how collaboration between disciplines can serve the coordination of the tender
- Disciplines can serve the coordination of the tender
  - Strategy 2 win is established:
    - Where to choose deliberate strategies (hierarchy), e.g. high or low quality EMAT
    - Where to leave open for strategic meetings to decide on the course of action

<table>
<thead>
<tr>
<th>Old Situation</th>
<th>New Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>attendants</td>
<td></td>
</tr>
<tr>
<td>Coordinating manager (SPC)</td>
<td>Coordination manager (margins)</td>
</tr>
<tr>
<td>Design manager (EPC)</td>
<td>Interdisciplinary coll. manager (relations)</td>
</tr>
<tr>
<td>Exploitation manager (MTC)</td>
<td></td>
</tr>
<tr>
<td>content</td>
<td></td>
</tr>
<tr>
<td>highlighting disciplinary incentives: ‘Tribal War’</td>
<td>Strategy 2 win weighted to project definition: ‘multilevel discussion’</td>
</tr>
<tr>
<td>result</td>
<td></td>
</tr>
<tr>
<td>Strategy 2 Win: focus on underlying incentives not colliding</td>
<td>Strategy 2 Win: focus on maintaining speed of workscopes</td>
</tr>
</tbody>
</table>

**Strategic Meetings (related to table 11)**
- Strategic meetings are chaired by the interdisciplinary collaboration manager, and attended by EPC and MTC manager, and EPC and MTC directors
- Discussion on how design choices can serve strategy 2 win
- Discussion on how collaboration between disciplines can serve design strategies
- Strategic choices are made for collaboration in the work scopes, work scopes are established by custodian:
  - Where to put hierarchy on work scopes (sequential process, top-down approach)
  - Where to leave open for network strategies in work scopes (slow track, bottom-up approach)

<table>
<thead>
<tr>
<th>Old Situation</th>
<th>New Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>attendants</td>
<td></td>
</tr>
<tr>
<td>Design manager (EPC), Directors D&amp;B, Exploitation manager (MTC) Directors M&amp;O</td>
<td>Coordination manager (margins) Interdisciplinary coll. manager (relations) Custodians (positions)</td>
</tr>
<tr>
<td>content</td>
<td></td>
</tr>
<tr>
<td>top-down strategic choices coordination&gt;strategic&gt;interdisciplinary</td>
<td>workscopes weighted to Strategy 2 Win: ‘multilevel discussion’</td>
</tr>
<tr>
<td>result</td>
<td></td>
</tr>
<tr>
<td>strategic flows: path prescribing design activities on workfloor level</td>
<td>workscopes: custodian appointed to determine to link work packages</td>
</tr>
</tbody>
</table>
**Interdisciplinary Meetings**

(related to table 12)

- interdisciplinary meetings are chaired by the interdisciplinary collaboration manager, and are attended by: custodians
- (and other lead engineers/architects), and EPC & MTC manager
- Discussion on how work packages can serve work scopes

- Discussion on how disciplines can collaborate in work scopes
- Work packages are determined:
  - Where to use hierarchy in design activities/analyses in work packages
  - Where to leave open for network options on workfloor level

### table 14 Interdisciplinary Meetings - Old and New Situation (Table by Author)

<table>
<thead>
<tr>
<th></th>
<th>Old Situation</th>
<th>New Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>attendants</td>
<td>Design manager, arch./eng. (EPC) Exploitation man., proj. man (MTC)</td>
<td>Coordination manager (margins) Interdisciplinary coll. manager (relations)</td>
</tr>
<tr>
<td>content</td>
<td>integration of parties and phases to employ execution of strategic flows</td>
<td>work packages weighted to workscope: 'multilevel discussion'</td>
</tr>
<tr>
<td>result</td>
<td>interdisciplinary analyses: analyses undertaken by two or more disciplines accomplished successful-ly by working together</td>
<td>work packages: interdisciplinary analyses and other design activities strongly interrelated bundled together</td>
</tr>
</tbody>
</table>

**D.5 Margins of Interdisciplinary Collaboration: Directives**

**D.5.1 MTC Directive**

For the adherence of MTC requirements, a directive is apprehended to the process, which prescribes the essential requirements for maintenance & operation. This is an internal document, which is updated for every dialogue phase. In the MTC directive, requirements are described qualitatively and quantitatively, and concern following levels:

Table 15 MTC Directive Specification (Graph by Author)

<table>
<thead>
<tr>
<th></th>
<th>Goal</th>
<th>Function</th>
<th>constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>- by demarcating what the important focal points are for M&amp;O services, the design process can be made more efficiently.</td>
<td>- MTC parties interpret and explicate the ‘soft’ terms (i.e. experiences, senses etc.) specified by the client and transcribe these into ‘hard’ constraints for the designing parties.</td>
<td>- level of abstraction is necessary, to leave open the interpretation of the designing parties (creativity, innovation), and to prevent that the MTC addresses their demands in a too early phase on a too high detail level.</td>
<td></td>
</tr>
<tr>
<td>- By offering a directive that sets out the boundaries on basis of hard criteria, the MTC can judge preliminary designs on a certain level of abstraction.</td>
<td>- By developing a MTC directive along with (preliminary) designs and service plans, the designing parties can ad hoc be directly ask to think with MTC issues, on a detail level that corresponds to the physical design.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**D.4 Discussion**

This improvement proposal starts from the notion that processes that work correctly, only are changed if room for substantive improv is acknowledged in the case study. As such, the proposal does not account for the day-to-day design activities of disciplines. Moreover, the number of management roles in the consortium is only increased by one: interdisciplinary collaboration manager. Other roles are adapted for better conduct of the consortium: custodians, and coordination managers. These roles serve respectively the purpose of:

1. conduct of project content (position)
2. collaboration process logistics (relation)
3. consortium competition coordination (margins)

It can be argued that the employment of an extra management role brings in extra organisation, and comes at extra costs, but it can be contended that a better management making the interdisciplinary collaboration process more efficient, might (drastically) decrease transactional costs. The roles have a distinct character (i.e. competition (margins), collaboration (relations) and content (positions)). In this way, the different responsibilities for the management are divided on a process level.
This adds to them discussing on different level; instead of representing a discipline or a consortium company (EPC, MTC), management now represent a link in the value chain. This adds to contend sectional interests.

Apart from roles, directives are given regarding M&O requirements: on basis of their interpretation of the output specification the MTC sets out the margins in which EPC parties can freely draft their design. MTC services are generally uniform, and by demarcating what the important focal points are for services, the design process can be made more efficiently. From the relations in the process, in terms of disciplines, domains and work packages, strategic flows materialise in work scopes under supervision of custodians. A scheme for this cannot be set beforehand, because it needs to account for a creative process, and iterations that emerge during this process. Work scopes instead of strategic flows are the focal points of the project: on basis of this the strategic team make strategic decisions and these are forwarded to the design teams. Custodians are responsible for work scopes: these convey different domains in which work packages have to be carried out. Having set out the (hierarchical) structures to guideline the collaboration process, on level of work packages disciplines are given space to perform their work in the way they are used to. Work packages contain interdisciplinary analyses that are bound by a certain subject. The work scope gives room for the discipline to explore different solutions for solving work packages in relation to: other work packages and work scopes in the project, other projects or other activities within the party’s own network. This freedom addresses the issue of network vs hierarchy.

In conclusion, by using these instruments, the consortium defines its own aims to confront the DBFMO competition: by means of making explicit the set-up for multilevel negotiation, it is purposed that efficient interdisciplinary collaboration can lead to a reduction of the transaction costs, lowering risk aversion and stimulating information sharing, thus relieving being caught between collaboration and competition.

D.6 Conclusion

Research subquestion D

“What are the instruments to optimise interdisciplinary collaboration to face the complexity of public tender DBFMO design competition?”

- In order to optimise the positions in interdisciplinary collaboration, to contend sectional interests management role shift: roles based on levels in value chain instead of consortium companies. Roles serve respectively the purpose of: conduct of project content (position), collaboration process logistics (relation) and consortium competition coordination (margins). This adds to them discussing on different level; instead of representing a discipline or a consortium company (EPC, MTC), management now represent a link in the value chain.

- In order to optimise the relations in interdisciplinary collaboration, the issue of network vs hierarchy is devised by creating involvement in actively monitoring interfaces and discipline-crossing activities:
  - Meetings are organised around the different levels in the value chain in order to create a multilevel discussion.
  - Custodians per strategic flow create workscopes: these convey domains in which work packages are carried out by disciplines.
  - The workscopes give room for the discipline to explore different solutions for solving work packages in relation to: other work packages and work scopes in the project, other projects or other activities within the party’s own network.

- In order to optimise handling the margins of interdisciplinary collaboration, the issue of being caught between collaboration and competition is relieved by means of making explicit the set-up for multilevel negotiation, it is purposed that efficient interdisciplinary collaboration can lead to a reduction of the transaction costs, lowering risk aversion and stimulating information sharing. MTC directives for better including M&O requirements furthermore helps to demarcate the focal points.

D.7 Limitations

This improvement proposal is limited to the extent of interdisciplinary collaboration process within a consortium.

Work Packages

In this research, interdisciplinary collaboration is looked at on the level of process; however, it cannot researched on level of content of work packages. This needs for (disciplinary) knowledge on the content and needs for understanding the cost implications of works, because the goal of work packages is to deliver output that can be used for cost administration. Parties all have target demands for design parts, and it is key that these align with the overall consortium budgets.
E. VALIDATION

“In the conduct of interdisciplinary collaboration is a underlying logic, but the reality is simpler, more intuitive” (Notenboom, 2014)
E. Validation

E.1 Methodology

SQ.E How are roles and instruments to optimise interdisciplinary collaboration evaluated by practice?

Validation is done on basis of interviews. The following interviewees (black bold lined) from the first set of interviews were approached for a second interview. First the results of the case study (ch. B) were presented, along with the perceived complexity of current DBFMOs (ch. C). Consecutively the roles and instruments for improved interdisciplinary collaboration (ch. D) was shown. In an open-ended interview, by confronting the Hoge Raad participants with the roles and instruments to optimise interdisciplinary collaboration, this was internally validated. The main peculiarities are described narratively below, along with a discussion. Finally, the conclusion reflects on the validity of the roles and instruments to optimise interdisciplinary collaboration.

E.2 Positions in Interdisciplinary Collaboration: Roles

E.2.1 Choosing an Interdisciplinary Collaboration Manager

In choosing the suitable persons for this role, Rutten and De Vaan (2015) underline the importance of choosing someone that is authorised to decide and to act, and (in case of the interdisciplinary collaboration manager) who is objective to disciplines. In case of an interdisciplinary collaboration manager, someone who has the authority from the contractor, but has knowledge from different disciplines, would be best fit for this job. Eekhof (2015) furthermore mentions that it is important to look for roles that mix a variety of competencies, backgrounds, history, relations etc. “Roles that are independent, give interesting dynamics to the process. One wants to win the project, from the consortium and not from the company perspective.” For a company this might not be advantageous, but for the consortium this creates another dimension: people are forced to look over the hedge of their own disciplines.

Discussion

The problem of interdisciplinary collaboration is that in order to have someone who has authority and is found knowledgeable, in almost all cases will find difficulties in being objective, because this person is most likely part of one of the disciplines. Another solution would be to bring in someone from an (building) party external to the consortium. However, such a person will find difficulties in having authority over the group. Moreover, the external IC manager gets an insight in the collaboration processes of other parties; it can be questioned if parties like this to share with others.

E.2.2 Shadows of the traditional process?

What if the roles introduced conflict with ‘traditional roles’? Wieland (2015) asserts that the overall design coordination, given per work scope to a custodian, ‘traditionally’ already lies with the architect, who also oversees on and controls interfaces. Wieland (2015) agrees that the architect is not knowledgeable to oversee all disciplinary works. In order to convey the complete work scope, the discipline must go beyond the boundaries of his own discipline. The architect is not the best fit-for-purpose custodian for all work scopes (e.g. work scope only relating to MEP and construction).

Discussion

The issues that can come with role changing and accustoming undeniably remain. The importance is that the focus lies on the process, to which disciplines can relate to, e.g. Custodians from an architectural discipline, but are involve with MEP issues, should confine themselves to the role of facilitating the work scope. The interdisciplinary collaboration manager’s task is to foresee on these matters.

E.2.3 Who can orchestrate or improvise?

In the ‘shadows from the traditional process’ parties are fulfilling their tasks on the time and detail they are ought to do in the traditional process. Wieland (2015) asserts that like the architect starts working on a preliminary architectural design for a facade, by researching materials and detail, MTC parties could parallel start working on a preliminary service plan for this facade. By doing this, MTC parties would not have to wait for the EPC to have finished their design, but can proactively steer the EPC. Eekhof (2015) underlines the importance of involving architects and others in developing the service plan: architects, for instance, have seen a lot of different spatial solutions for our service rooms such as restaurants.

“If the MTC were able to assign others using a directive, they would attach more value to the process; in the current process they simply said it was possible or not” (Wieland, 2015).

Discussion

By means of the MTC directive, the MTC parties are more actively enforced to start thinking about their requirements; rather than waiting for details to come from the design parties, they will be enforced to think how their directives given will steer the design. By updating the directives along the competition, the service plan can develop parallel. By means of the MTC directive, they are given a small step ahead, in order to have their wishes safeguarded.
E.2.4 Who takes the lead in a work scope?
The case study reveals that ‘first come, first serve’ is applicable to the collaboration process: disciplines that take the initiative, in case a trade-off has to be made between different disciplines, often yield the best result (Wieland, 2014). In response to the roles and instruments to optimise interdisciplinary collaboration, Wieland (2015) extends this by saying that individuals acclaim the role of a custodian, in the current process. In a more structured process, there is someone appointed to be in charge per work scope (custodian). On the other hand, Wieland (2015) discusses that for many design decisions, no one feels responsible to make the decision. In the end, all parties like someone to make the final decision. Due to all disciplines being placed on the same level of hierarchy, the idea exists that compromises are made, and thus every party will be satisfied. Wieland (2015) cautions that this is not the case: there are always winners and losers.

Discussion
In relation to responsibility, the roles and instruments to optimise interdisciplinary collaboration offer more tangible grips to appoint people to be responsible responsible. The introduction of custodians, who guide a work scope, gives them the responsibility on level of the work scope (process), thus also gives him the responsibility to steer work packages (content). Disciplines performing the work package on their turn, might feel more related to the work scope, because they can influence the key elements (work packages) that shape them.

E.3 Relations in Interdisciplinary Collaboration

E.3.1 Meetings: orchestrate or improvise meetings?
What is the necessity of so many meetings? How can we reduce the transactional costs? Wieland (2015) mentions that if disciplines need each other, they know how to find each other for meetings. If conflict arises, this is forwarded to the strategic or coordination meetings, and then the final responsible persons decide on action. Kok (2015) names the inefficiency of interdisciplinary meetings for the MTC: “meetings would endure for 3 hours, and 80% was not relevant for the MTC.” This was very time intensive, but it was necessary to attend, because it cannot be known beforehand if design decisions would affect maintenance & operate.

Discussion
In the new structure of meetings the number of meetings is not declined. It is foreseen that due to the clearer role distinction between process managers (IC manager) and project managers (EPC, MTC), and dividing the work scopes over custodians, the number and duration of meetings will decrease. In this case it is purposely chosen that the choice for meeting amounts, lengths etc. is left with the consortium to set themselves.

E.3.2 Work scopes; timeliness of operations?
How can timeliness be guaranteed? How can work scopes be made simple and efficient? For the operationality of work scopes the aspect of time is important. Flamink (2015) underlines the importance of kick-starting the competition: now much time is needed for the logistical procedures accompanying interdisciplinary collaboration. It would be an improvement if the consortium could move on to the core of the content faster. During the competition, time between the dialogues is scarce, so everyone ideally should be able to start doing their core tasks right away. Moreover, in order to control the rebate mechanism better, it is important to know in which phase what rebates are applicable (Flamink, 2015). Timeliness also pertains to consortium establishment: Flamink (2015) mentions that already during the prior information notice by the client, work scopes would be useful for consortium initiators to start exploratory talks with other parties.

Discussion
By mapping out all work packages in work scopes, and having set out the basis for all meetings, disciplines will be better informed about the delivery times.

E.3.3 Work scopes: length of activities?
Wieland (2015) admits that the proposed work scopes give speed to the process: “at the moment choices have to be made, you know that all check boxes have been checked, and you are assured that a decision can be made“. However, Wieland (2015) underlines that a work scope gives a certain anticipated length to activities, but opposes by saying that due to other design activities undertaken parallel in the process, activities can be influenced. De Vaan (2015) acknowledges that there is a danger in working with a scheme: one might assume that the whole process works as projected in a block scheme; the reality is much more intuitive. Wieland (2014) names that it also is dependent on the detail level: “if the client approves the design, specialist analyses (structural, fire engineering etc.) can start, but when the shape is not determined, this is very difficult. Everything is interrelated.”

Discussion
Leaving open the process for parties to discover themselves what the duration of work packages is, is foreseen to give the parties a better feeling of responsibility for the end result. Although room is given, the responsibility for the work package is put black on white in a work scope, and they cannot deviate from this anymore. Therefore, although work
packages are established in content, the execution of them are decided by the disciplines, and thus leave open for an 'intuitive' approach.

E.4 Margins of Interdisciplinary Collaboration

E.4.1 Output/Cost efficiency: how much detail do we need?
Flamink (2015) questions names that it is important that it can be assessed what detail of output is necessary for the tender: is the end result focused on the tender offer, or on pricing for the consortium? As main importance for making the output/cost ratio more efficient, it needs to be clarified per work packages what the end result is: are choices for expenses aimed at delivering an advantageous tender or on consortium pricing? How can the costs of tender be diminished? (Flamink, 2015)

Flamink (2015) suggests that if parties know the work scope, it can be used to analyse the rebate mechanisms.

Discussion

In order to make the work scopes usable for cost determination, interfaces need to be mapped. The advantage of the work scopes are, that if correctly priced, the cost drivers become visible: the strategic flow is directly valued in monetary terms. In further research, it can be assessed how universal cost

E.5 Conclusion

Research subquestion E

“How are instruments to optimise interdisciplinary collaboration recognised by practice?”

- Regarding the positions in interdisciplinary collaboration, the choice of the right people for the right places in interdisciplinary collaboration is crucial. For the role of the interdisciplinary collaboration manager, a consortium looks for a person who is objective, knowledgeable and authoritative. In the practical execution of the instruments to optimise interdisciplinary collaboration this can be a challenge.

- Regarding the relations in interdisciplinary collaboration, the new role distinction that divides between process and content should be made explicit to all disciplines. The ‘shadow of the traditional process’ is prevented if managers keep the focus on the process. Taking the lead is actively imposed on the MTC, by means of establishing the MTC directives. This gives them given a small step ahead, in order to have their wishes safeguarded.

- Regarding the margins of interdisciplinary collaboration, interfaces need to be mapped to make work scopes usable for cost determination. By mapping out all interfaces in workscopes, and having set out the basis for all meetings, disciplines will be better informed about the delivery times. These delivery times are dependent on negotiated work package durations. Interfaces and overlay will still be apparent, but by making the workscopes explicit, it is better foreseeable.

E.6 Further Research

E.6.1 Work Packages: what is the content?
Wieland (2015) notices that work packages are difficult to compound in scope. For the building construction industry, work packages contain many interfaces. The disadvantage of work packages is that it is difficult to provide insight into what the impact is of change on one work package for others. Wieland (2015) continues by saying that this might develop into a big network of different work packages. If one discipline changes a design element, all other disciplines all have to change with him.

Discussion

For the roles and instruments to optimise interdisciplinary collaboration, different packages are clustered in work scopes. Undoubtedly interfaces and overlay between work packages might exist, but by making the work packages visible, it is easier for parties to perceive these. Consecutively, it is easier to approach one another for collaborative action.

E.6.2 Other contract structure SPC>MTC> EPC

From the perspective of interdisciplinary collaboration, the consortium could consider to change the contract structure for the organisation after competition win. As seen from the exploitation, Flamink and Kok (2015) argue that it would be an improvement if the MTC was placed hierarchically above the EPC. The MTC bears a long-term responsibility, and thus has to control (far-reaching) M&E consequences of certain design decisions. Kok (2015) asserts that there should be one entity that designs in principle: the MTC coordinates the EPC, and the EPC on their turn coordinates architect, contractor etc.

In this new structure interface risks would cease to exist: Flamink (2015) explains how the current interface contracts cover the juridical risks that cannot be foreseen. In a new situation the SPC would draft a DBMO contract with the MTC to guarantee that all DBFMO aspects would be covered. The MTC, on their turn would sign a DB contract + (remaining) interfaces-contract with the EPC (Flamink, 2015). Kok (2015) adds to this, that this would provide a much more straight line in the organisation structure: “There is no need for an interface contract anymore, the MTC directly steers the contractor”. Kok (2015) furthermore underlines that this would diminish the transactional costs, because this structure would exert more hierarchical decision-making.
In order to better bring input from the MTC parties into the process, on the one hand custodians can better foresee on MTC input, yet on the other hand placing the MTC contractually above the EPC after competition win, could lead to the MTC more actively steering the EPC (Kok, 2015). Wieland (2015) opposes this: he states that the MTC, apart from their M&O constraints given, has no interest in the output of the design. The MTC would during the competition farther insist on design options that would enhance the functionality of the building. Wieland (2015) admits that such a structure could possibly function if the MTC would be as informed about the output specification as the EPC, which would change their role completely.

discussion

Changing the contract structure to a hierarchical, might solve the interfaces-issue, but it might also lead to a too strong influence of the MTC on the design. ‘Directives’ given by collaborating disciplines on the same hierarchy level, aim at disciplines to start to think from the other one’s perspective (because they have to); yet, in a hierarchical contract structure there is not a need from the leading party to argue his choices.
F. CONCLUSION

“In the conflicts, ideas emerge that make the building outstanding. It is about creating a process in which conflict is conducted in a controlled manner”
(Vola, 2015)
F. Conclusion

F.1 Research Conclusions
The main research objective is described as:

MO  To find roles and instruments to optimise collaboration by finding the origins of collaboration deficiencies

The research objective was split into three different sub objectives (positions, relations and margins), which all together contribute to the main research objective. The sub objectives served as a categorisation for the answers to the main research question, which was denominated:

MQ  How can interdisciplinary collaboration be optimised to face the complexity of a Dutch public tender DBFMO design competition?

In order to answer this research question, five sub questions for research were defined, that were answered in the five distinct chapters.

This paragraph has the following outline:

F.1.1 Conclusion on the positions in interdisciplinary collaboration
- The theoretical context directs at disciplinary interests that have to be merged to control design risks in interdisciplinary collaboration. Moreover, insufficient knowledge sharing hampers team processes and can be attributed to ‘shadows of the traditional process’: a sequential and fragmented design, which is due to adversial business contexts and insufficient time structuring.
- The case study shows that complexity in controlling design risks manifests as both D&B and M&O parties are not used to linking of M&O aspects to a design project. Complexity in disciplinary knowledge sharing embodies as requirements from follow-up phases bring risk of design issues that cannot be located with a single discipline or DBFMO term.
- This complexity can be explained by sectional interest, the contractual constructs fence off an overall responsibility for the design. Therefore, disciplinary knowledge sharing is needed; a shared understanding can deliver creative coupling.
- Instruments to contend sectional interests management role shift: roles based on levels in value chain instead of consortium companies. Roles serve respectively the purpose of: conduct of project content (position), collaboration process logistics (relation) and consortium competition coordination (margins). This adds to them discussing on different level; instead of representing a discipline or a consortium company (EPC, MTC), management now represent a link in the value chain.
- In the implementation of instruments in practice, the choice of the right people for the right places in interdisciplinary collaboration is crucial. For the role of the interdisciplinary collaboration manager, a consortium looks for a person who is objective, knowledgeable and authoritative. In the practical execution of the instruments to optimise interdisciplinary collaboration this can be a challenge.

In summary:

A shift of management roles is introduced, that serves the purpose of letting disciplines discuss on different levels, instead of representing a disciplines or consortium company. In finding the right people for these roles, it is important to take into account objectivity, knowledgeability and authority.

F.1.2 Conclusions on the relations in Interdisciplinary Collaboration
- The theoretical context presents a difference in organisational approach of parties:
  - urge to understand the different levels of control for the DBFMO design process, but the current organisational structures result in fragmented interests and non-collaborative working.
- The organisation of a DBFMO consortium struggles with client satisfaction and process management, due to insufficient knowledge on integration and focus on interfaces between different disciplines and award criteria.

- The case study shows that a difference in organisational approach of parties makes relations in interdisciplinary collaboration more complex: Top-down decisions (strategic flows) were insufficiently controlled by a scope of work that can be controlled. Design issues need to be prioritised. In the case study, prioritisation is done by hierarchy and power-play of disciplines. Moreover, collaboration inefficiencies remain to exist because of structuring the meetings:
  - Design choices based on power-play were stipulated on a high level and the consecutive strategic flows were insufficiently controlled by a scope of work for the work floor level.
  - The meetings need to be categorised per subject instead of separating parties

- Approaches to project activities lead to design decisions made on different levels: design activities can best develop in a sequential process; other activities demand for researching in a network. Collaboration in a DBFMO consortium can be seen as working in a hybrid organisation: a sequential (hierarchical) process forms the basis, from which can be deviated, for disciplines to start working in a network. By leaving open use of external network, cooperation and a process chain, within the hierarchy of the project conduct network characteristics can be opportuned.

- In order to optimise the relations in interdisciplinary collaboration, the issue of network vs. hierarchy is devised by creating involvement in actively monitoring organisational levels, interfaces and discipline-crossing activities:
  - Meetings are organised around the different levels in the value chain in order to create a multilevel discussion. These meetings serve respectively the purpose of:
    1. project content (position)
    2. collaboration process (relation)
    3. coordination of competition (margins)
  - Custodians per strategic flow create workscopes: these convey domains in which work packages are carried out by disciplines.
  - The workscopes give room for the discipline to explore different solutions for solving work packages in relation to: other work packages and workscopes in the project, other projects or other activities within the party’s own network.

- Regarding the relations in interdisciplinary collaboration, the new role distinction that divides between process and content should be made explicit to all disciplines. The ‘shadow of the traditional process’ is prevented if managers keep the focus on the process. Taking the lead is actively imposed on the MTC, by means of establishing the MTC directives. This gives them given a small step ahead, in order to have their wishes safeguarded.

**In summary:**

An understanding of the different levels of control for the DBFMO design process cannot be achieved due to fragmented interests and non-collaborative working. The organisation struggles because of insufficient knowledge on integration and focus on interfaces. Practice shows that a misfit between top-down decisions and work floor, remain to exist because of the meeting structures: design choices based on power-play were stipulated on a high level and the consecutive strategic were insufficiently controlled by a scope of work for the work floor level. This can be explained by a difference in approach to disciplinary activities: network vs. hierarchy.

The issue of different approaches to activities can be contended by creating involvement in monitoring organisational levels, interfaces and discipline-crossing activities: meeting structure organised around the different levels in the value chain, and workscopes and work packages on work floor level provide disciplines the room to perform in their own way-of-working using their own networks. Role distinction between process and content is important in the practical execution.

**F.1.3 Conclusion on the margins of interdisciplinary collaboration**

- The theoretical context exhibits a disparity between competition and collaboration:
  - The client’s output specification constrains interdisciplinary collaboration, and the effect is two-sided: a basic and functional design demand (positive), and a narrowly defined service-output specification (negative) oppose each other.
  - Contractual division between the EPC and MTC due to competition outline does not bring holistic responsibility.

- In the practice of the Hoge Raad project, the consortium struggled with controlling this disparity:
  - A changing client demand and rebate mechanism are insufficiently interpreted and can be explained by parties not being used to a service-led contract.
  - Different accounting systems for the expenses leads to ignorance between EPC and MTC in understanding each other’s demands/supplies.

- Interdisciplinary collaboration is externally pressurised by margins set out by the client and
by the consortium itself. The increased outsourcing of activities by the client in a service-led contract that is awarded in a strictly regulated competition leads to imbalance in effective dialogue and keeping information in the consortium.

- In order to optimise handling the margins of interdisciplinary collaboration, the issue of being caught between collaboration and competition is relieved by means of making explicit the set-up for multilevel negotiation, which explains the issues the . MTC directives for better including M&O requirements furthermore helps to demarcate the focal points.

- Regarding the margins of interdisciplinary collaboration, interfaces need to be mapped to make work scopes usable for cost determination. By mapping out all interfaces in work scopes, and having set out the basis for all meetings, disciplines will be better informed about the delivery times. These delivery times are dependent on negotiated work package durations. Interfaces and overlay will still be apparent, but by making the work scopes explicit, it is better foreseeable.

In summary:

Interdisciplinary collaboration is hindered by a disparity between competition and collaboration: the outlines specification has a twofold effect which opposes each other, and contractual division due to the competition outline does not bring holistic responsibility. In practice, a changing client demand and rebate mechanism are insufficiently interpreted, and contractual division leads to ignorance in understanding each other’s demands/supplies. Collaboration is pressurised by the competition, and leads to imbalance in effective dialogue and keeping information in the consortium. The handling of margins is ameliorated by making explicit the steps in creating the competition deliverables. Moreover, delivery times can be better controlled. MTC directives support the inclusion of M&O requirements.

In the practical execution, the mapping of interfaces in work scopes and setting out of meetings are important for informing disciplines about the delivery times.

F.1.4 Conclusion on the main research question

**MQ**  
*How can interdisciplinary collaboration be optimised to face the complexity of a Dutch public tender DBFMO design competition?*

Interdisciplinary collaboration can be optimised by the following:

- A shift of positions of disciplines in interdisciplinary collaboration, to overcome the habits of a sequential and fragmented design, and to see risks of design issues in a holistic view. Disciplines must discuss on different levels, instead of representing a discipline or consortium company.

- Meetings structured around the different levels in the value chain, to create involvement in actively monitoring organisational levels, interfaces and discipline-crossing activities. Work scopes and work packages on work floor level provide disciplines with room to perform their own-way-of-working using their own networks.

- Steps in creating the competition deliverables are made explicit by means of work scope and work packages, by which delivery times can be better controlled. MTC directives support a better inclusion of M&O requirements.

Table 16 Overview Output - Objectives (Graph by Author)

<table>
<thead>
<tr>
<th>Objective</th>
<th>Output</th>
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<tbody>
<tr>
<td><strong>Objectives</strong></td>
<td><strong>Output</strong></td>
</tr>
<tr>
<td>- To find how different strivings of disciplines to optimise project outcomes can be reconciled</td>
<td>• Tables for management role division: o roles o tasks o custody o meeting attendance</td>
</tr>
<tr>
<td>- To discover how fragmented interests in the competition can be pooled</td>
<td>• Scheme for an improved collaboration process for delivering the value chain. o Tables for meeting structures</td>
</tr>
<tr>
<td>- To identify how inefficient collaboration between disciplines can improve</td>
<td>• To discover how disciplines can improve value of their works, living up to the rules of the competition and consortium rules-of-play.</td>
</tr>
<tr>
<td>- To find how an overall non-collaborative working between disciplines can be resolved</td>
<td>Table for MTC Directives: o Goal o Function o constraint</td>
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<tr>
<td>Research Subquestions</td>
<td>How can interdisciplinary collaboration be optimised to face the complexity of a Dutch public tender DBFMO design competition?</td>
</tr>
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<td>------------------------</td>
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</table>
| SQ.A What is the theoretical context of interdisciplinary collaboration for Dutch public tender DBFMO design competitions? | • Inefficiencies between the different disciplines in terms of collaboration and the striving to optimise project outcomes (Sogol, 2010).  
• Disciplinary interests have to be merged to control design risks  
• Insufficient disciplinary knowledge sharing because of sequential and fragmented design, adversarial business contexts and mere time structuring  
• Top-down-down decisions were not embodied by a scope of work that could be controlled.  
• Design issues need to be prioritised.  
• Programming demands for an anticipation of all interfaces in the project.  
• Client’s competition instruments constrain collaboration, and the effect is both positive and negative  
• Contractual division due to competition outline does not bring holistic responsibility. |
| SQ.B Where does complexity manifest in the practice of interdisciplinary collaboration in a Dutch public tender DBFMO design competitions? | • Complexity in control: Both D&B and M&O parties are not used to linking of M&O aspects to a design project.  
• Complexity in knowledge sharing: demands from follow-up phases bring risk of design issues that cannot be located with a single discipline nor a DBFMO category  
• Different ways of working result in a top-down respectively a bottom-up approach to the collaboration process.  
• Changing client demand and rebate mechanism are insufficiently interpreted, parties are not used to a service-led contract.  
• Different accounting systems lead to ignorance between EPC and MTC in understanding each other’s demands/supplies |
| SQ.C What is the explanation for perceived complexity of interdisciplinary collaboration in Dutch design competitions? | • Due to sectional interest, traditional views on building processes endow differences in thinking of future changes/adaptations of the building.  
• External pressure by increased outsourcing of activities by the client in a service-led contract in a strictly regulated competition.  
• Management roles shift: roles based on levels in value chain instead of consortium companies.  
  • conduct of project content (position),  
  • collaboration process logistics (relation)  
  • Consortium competition coordination (margins)  
• Creating awareness for interfaces and discipline-crossing activities:  
  • Custodians per strategic flow create work scopes  
  • Work scopes give room for the discipline to explore different solutions  
• Making explicit the set-up for multilevel negotiation, which can lead to a reduction of transaction costs, lowering risk aversion and stimulating information sharing.  
• MTC directives for better including M&O demands |
| SQ.D What are the roles and instruments to optimise interdisciplinary collaboration to face the complexity of public tender DBFMO design competition? | • The new role distinction should be made explicit to all disciplines. The ‘shadow of the traditional process’ is prevented if managers keep the focus on the process.  
• The choice of the right people for the right places in interdisciplinary collaboration is crucial. In the practical execution this can be a challenge.  
• The choice of the right people for the right places in interdisciplinary collaboration is crucial. In the practical execution this can be a challenge.  
• The choice of the right people for the right places in interdisciplinary collaboration is crucial. In the practical execution this can be a challenge.  
• Interfaces in work scopes mapped out for cost determination.  
• Work packages in work scopes mapped out for better information about the delivery times.  
• A shift of positions of disciplines, to overcome the habits of a sequential and fragmented design, and to see risks of design issues in a holistic view. Disciplines must discuss on different levels, instead of representing a discipline or consortium company.  
• Meetings structured around the different levels in the value chain, create awareness for organisational levels, interfaces and discipline-crossing activities. Work scopes and work packages provide disciplines with room to perform their own-way-of-working.  
• Steps in creating the competition deliverables are made explicit by means of work scope and work packages, by which delivery times can be better controlled. MTC directives support a better inclusion of M&O requirements. |
F.2 Limitations

The main limitations of the methodology of the research can be described as follows:
- Literature choice is limited. I used literature arbitrarily. It can argued that using the variables from literature study does not fulfil the requirement of construct validity (Yin, 1998).
- In the case study, despite the fact that I tried to depict a truthful representation of the daily practice, generalisability and utility of findings could be a result of my subjective interpretation.
- Interviews have produced an internal validation of the above-mentioned arbitrary decisions, and made a contemplation of linkages of analyses (internal validity, reliability) possible. However, these do not go into detail and cannot directly be extrapolated to other projects (external validity).
- Furthermore, a single-case research is constrained as the interview sample size is limited. Only a relative small number of participants could be questioned. Due to this small sample size, it is arguable if the given results could be generalised.
- The method used for collection of data may have been biased. This might be due to the theoretical preparation of the interviews. In addition to the methodological limitation, there are also longitudinal constraints. The time available to conduct my research was constraint by due dates and interviewees’ availability.
- This thesis research does not provide external validity so as that its research results can be extrapolated to other DBFMO design competitions.

The main limitations of the scope of the research can be described as:
- This thesis research regards the collaboration as it is, within the organisational and contractual framework given by the SPC. It can be disputed, however, if this organisational and contractual framework as deployed now, promotes interdisciplinary analyses in the best way.
- This thesis research does not provide external validity so that the research results can be extrapolated to other DBFMO design competitions. However, interviewees have experience with other DBFMOs, and reflect on the basis of this experience. As such, external validity may be indirectly achieved, as explained by Lincoln & Guba (1986). Research results can be transferred to situations with similar parameters, populations and characteristics.

F.3 Research in Perspective

F.3.1 Academic Perspective
This research contributes to the management sciences of interdisciplinary collaboration in integrated building construction projects.

The practice of DBFMO competitions exemplifies the growing need for reforms within the building and construction industry in order to face present and future transitions. The construction industry is currently under a lot of pressure, as there is an increasing need for greater transparency, client orientation and innovation. Furthermore, today’s society is longing for a shift towards more sustainable solutions. For instance, the life cycle aspects of buildings, quality assurance and coherency assurance are gradually getting more and more attention. In addition, there is a growing involvement and influence from interested parties in the construction process, and collaboration between disciplines.

There is a demand for more scientific investigation into interdisciplinary collaboration. The outlined complexity of interdisciplinary collaboration in a DBFMO design competition brings together aspects from different researches focused on different aspects of the DBFMO (e.g. disciplinary positions, role division, competition set-ups). Therefore, this research has a new (more generalist) approach to the subject.

F.3.2 Practical Perspective
The establishment of a consortium for a DBFMO competition is a black box for all parties (Notenboom, 2015): not only the public clients and external building parties, but also the consortium partners themselves, urge to get hold on activities during the DBFMO collaboration process. Estimations have to be made at an early point in the design phase, to anticipate on coming phases. Risks that come with these estimations lead to large budget margins and misinterpretations between parties lead to high failure costs. Changes in responsibilities of parties in a DBFMO demand for a better understanding of the positions and relations of single disciplines in consortium collaboration. Differences in behaviour of and expectations of parties frustrate the coming together of an optimal interdisciplinary collaboration (alignment).

The constituted improvement proposal for Hoge Raad der Nederlanden is a first example for interdisciplinary collaboration in a Dutch DBFMO design competition, unrelayed into detail. As every competition is different from one another, the proposal will not be directly applicable to other DBFMO projects. However, by making explicit what steps can be taken for a better interdisciplinary collaboration, there are starting points for setting up collaboration in a new project. Regarding the following applications of
the improvement proposal, the following is reflected by practice:

- MTC directives: the possibility to add an internal M&O output specification to client’s OS is technically feasible through use of Relatives-software (De Jong, 2015). This gives the possibility to make a roadmap for in which phases to implement certain specifications. However, this is not yet used right now. The MTC directives could give an extra push in acclaiming this.
- Improvement proposal usage for contracts between contractor and advisor for packages of multiple DBFMO projects: Although, even in projects with the same parties, the DBFMO projects are different. However, after a first project, using this outline for collaboration the project can be evaluated and new resolutions can be made for the next project.

For Arup specific, following application is considered:

- Use for Arup if it decides to become lead consultant in a consortium for specific projects (Vola, 2015): the recommendations for an external process manager come to the benefit if the engineering specialist leads the project.

F.3.3 Personal Perspective

The practice of the DBFMO necessitates a scientific research into the ‘objective’ management of collaboration processes. Different disciplines approach the process from their own frame of reference, but are pressed to use the framework of the leading discipline. This can lead to mismatches in collaboration that can actually be attributed to different ways of working.

From my own observations in this research process, I can underline that being ‘objective’ can be very difficult. As the researcher, I experienced that in contemplating in a holistic view, it is very difficult to estimate the interests of all disciplines. As my background lies in architecture, I am inclined to think that the approach of the architect as the leading manager in consortium collaboration is the best. In interviews with other disciplines, I found that others had very different views on this.

F.4 Reflection and Evaluation

In this paragraph, I reflect on the graduation research project and process. As for this graduation project, merging practical observations with theoretical frameworks was essential, I will reflect on the methodology, data collection and results. Moreover, I evaluate the problem statements, research questions and relevance. First the research process in chronological order is reviewed, to reflect on steps taken and difficulties faced.

F.4.1 General process

This thesis research with the (final) subject of interdisciplinary collaboration in DBFMO design competitions started with the subject of BIM collaboration (in DBFMO). This subject choice stems from my interest in the way different disciplines collaborate in complex building construction projects.

BIM, as a relatively new method for direct collaboration between different disciplines in design, construction, maintenance & operation processes, is still at a very early stage. Researching what the options are to optimise collaboration in this regard seemed expedient. Starting with the broad topic of Building Information Modelling, the scope of research had to be narrowed down, in order to come to tangible demarcations of the interdisciplinary process that would be viewed upon. The DBFMO contract, which requires different disciplines to collaboratively serve the Design, Build, Finance, Maintenance & Operation aspects of a building, made an excellent and obvious choice. However, during the process I found out that researching the theory and practice of BIM in a DBFMO project would imply finding a technical solution for a phenomenon, which in itself was not entirely clear. The research scope now shifted towards the joint efforts made by parties to aggregate their disciplinary knowledge during the DBFMO design competition. In these design competition, in this case for publicly tendered projects in the Netherlands, parties have to come to such a design in due time and within copious rules set by the client.

As such, the research started to focus on interdisciplinary analyses by means of a case study into the Hoge Raad der Nederlanden. I researched how disciplines collaboratively start looking for the possible ‘risks’ of their parallel and collaborative designing on the same design during the design competition. By starting with a project documentation study, which were my own insights, I came up with analyses. Consecutively, these were categorised and placed on different timescales, in order to discover different linkages between analyses, and assume how these might be correlated. By means of interviews, I sought a narrative description of how these analyses were established in the project, and to find a first validation of my assumptions on the basis of the project documentation study. Interviewees clarified that interdisciplinary analyses could not be seen as a consolidated series of activities. Moreover, analyses were strongly intertwined with the whole process of interdisciplinary collaboration (in publicly tender Dutch DBFMO design competitions). At this point, the research took flight again. During the mid-term meeting, I discussed? a first complete version of the case study. During this meeting, it became evident that the collaboration process in the case study could be scrutinised more, in particular research could be conducted into the ‘underlying interests’ of disciplines that caused certain behaviour in interdisciplinary
collaboration. Also, at this point, the end terms for this research needed to be defined.

As the case study into Hoge Raad showed, every DBFMO design competition has its own specific characteristics that are unique per country, client, competition, consortium, roles within the consortium, parties playing these roles, and so on. It therefore was decided to focus this thesis research on a single case study, with results based only on this one, but for other cases to refer to. In order to assess possibilities as to how the collaboration process in this particular case could be optimised, on the basis of the observations from the case study, phenomena that emerged during the collaboration process were described. Now, it could be seen that certain phenomena that appeared to be ‘novel’ in a DBFMO design competition, had analogous counterparts in other (collaboration) processes. From additional literature study, apparent phenomena (i.e. locked in sectional interest, network vs. hierarchy, caught between competition and collaboration) could be described. From this understanding how certain behaviour in interdisciplinary collaboration evolved, it became clear how an improvement solution tailored to the Hoge Raad project would look like. In retrospect, it can be questioned if optimisations on the project level (Hoge Raad) can be directly distilled from general phenomena that I identified. Nonetheless, these make interdisciplinary collaboration in DBFMO design competitions more comprehensible. Further research could explain how these phenomena actually emerge, and secondly, how direct effects onto interdisciplinary collaboration can be foreseen.

F.4.2 Problem statement, research questions, relevance

The problem definition is based on literature research, conducted before the case study was initiated. In hindsight, this was a good choice: problems were described objectively in academia, and were not interfered with project-specific problems that materialised in the Hoge Raad project. The problem definition comprised different (interrelated) deficiencies (e.g. collaboration terms and striving for project outcomes (Sogol, 2010), and Fragmented interests in competition sections (Straub et al., 2012)), which were at that point quite abstract.

Upon starting the case study, there was not a direct line to be found between the research question (“How can interdisciplinary analyses be optimise for DBFMO design competitions?”) and the problem definition (deficiencies in interdisciplinary collaboration). At this point, I anticipated that conclusions on the basis of linkages and correlations between analyses found would lead to the answer how to resolve collaboration deficiencies. At that point, it was not foreseen that it would require external references (phenomena describing the complexity of interdisciplinary collaboration) in order to comprehend the problem. In the end, these external references give a good understanding of the actual problem, and provide directives for resolving these deficiencies. However, for the roles and instruments to optimise interdisciplinary collaboration, these directives have been tailored to implementation in the Hoge Raad project. It could be debated whether conversion to the actual improvement proposal is optimal: the step between describing general phenomena and tailored actions for improving the DBFMO design competition is ill-defined. An in-depth study into this conversion would be a topic for further research.

From the interviews for the case study research, and reflection on the improvement proposal, it appears that the research efforts of this thesis run parallel to the current strivings of consortiums in DBFMO design competition to comprehend interdisciplinary collaboration. Examples discussed by interviewees about their experiences with other DBFMO projects outlined the general efforts been done to better understand this topic. It can be seen that in the practice of the building construction sector, there is less attention for the actual management of collaboration processes. In DBFMO particular, mostly contractors lead these projects, and their approach to the collaboration process is very pragmatic. On the other hand, the other disciplines (e.g. architect, engineer), although they all approach the process from their own frame of reference, will be imposed the framework of the contractor. Obviously, this can lead to mismatches in collaboration (organisation, meetings, methods, detail) that can be simply attributed to (underlying) different ways of working. As such, it becomes apparent that external scientific research into management is relevant. Research conducted externally and objective from disciplinary views can provide with answers.

F.4.3 In Conclusion

The general process for this thesis research provided an interesting peek into the complexity of interdisciplinary collaboration. The interest for collaboration processes between different disciplines in the building construction sector is reflected in this thesis research. However, different paths have been taken to view this subject. Starting with current technical methods to cope with interdisciplinary collaboration (BIM), the research evolved by researching interdisciplinary collaboration and its deficiencies, and later, the underlying reasons for interdisciplinary collaboration and its deficiencies. This is placed within the framework of Dutch publicly tendered DBFMO design competitions. The result of this thesis research provides an optimised solution for a single case study studied. The solution presented is tailored to the Hoge Raad project specifically, but can be used as reference for other Dutch publicly tendered
DBFMO design competitions. Measures to overcome deficiencies in interdisciplinary collaboration have been described from a study into external references to phenomena observed.

**F.3 Recommendations for Arup**

This research was performed within Arup Amsterdam, in collaboration with the other participating parties of the *Hoge Raad* project. As Arup is involved in more DBFMO projects (under Dutch publicly commissioned design competitions), I would like to give the following recommendations for future projects:

1. **Formalise the envisioned position of Arup as engineer in DBFMO competitions**
   Arup is a multidisciplinary design organisation involved in copious interdisciplinary design projects. As the *Hoge Raad* project showed, it is important that disciplines nail the colours to the mast: by addressing their foremost characteristics, others will discover interfaces and will actively search for collaboration.

2. **Practice the use of the proposal for ideal collaboration by means of internal workshops**
   DBFMO requires the understanding of different paradigms of the disciplines involved. This is something that can be best learned from practice. Sharing practical knowledge, and utilising the different disciplinary knowledge within Arup, could make it possible to simulate interdisciplinary collaboration in workshops.

3. **Use the schemes for an optimised collaboration for discussion meetings for the establishment of consortiums**
   The outlined scheme can be used as in consortium establishment to quickly inform other disciplines about Arup’s methodology for consortium collaboration.

4. **Stimulate further research on interdisciplinary collaboration in general**
   Interdisciplinary collaboration deserves more attention, considering the emerging of integrated contracts. For recommendations for further research, reference is made to E.4.

**F.4 Recommendations for Further Research**

The thesis research has brought to the table many interesting other aspects that sideways have been touched upon:

1. **Content of Work Packages and Output**
   In this research, interdisciplinary collaboration is not researched on the level of content of work packages. The goal of work packages is to deliver output that can be used for cost administration. From this thesis research, the improvement proposal can be used to frame work packages, and on the basis of practical insights and knowledge of cost administration, work packages can be compounded.

2. **Client position in DBFMO competitions**
   In this research, interdisciplinary collaboration is looked at from the level of process; however, it would be worthwhile to look at the interpretation of output specifications, award criteria and dialogues, by individual disciplines.

3. **Consortium contract structures in DBFMO competitions**
   Different possibilities of change of consortium contract structures could be argued to endow interdisciplinary collaboration, from different perspectives, e.g:
   - The perspective of EPC
   - Alliancing (client involvement)
   - Moving interfaces to either EPC or MTC.

4. **Usage of BIM in DBFMO (design competitions)**
   The *Hoge Raad*, as the first top-down obligated implementation of BIM in a DBFMO after a competition win in the Netherlands, has brought many issues regarding interdisciplinary collaboration to the table. In this light, ‘BIM usage in DBFMO (design competitions)’ provide a basis for extensive research.

5. **Traditional phasing in the light of DBFMO**
   As this thesis research shows, traditional phasing in DBFMO competitions becomes less important due to the competition’s time structuring. Terms, such as ’preliminary design+’ or ‘++’ are named to designate the demanded detail for documents. However, a new scale of detail for DBFMO needs to be defined.
PART G
LITERATURE
G. Literature


Blanken, A. (2008). Flexibility against efficiency?: an international study on value for money in hospital concessions: University of Twente.


PART H
APPENDICES
Appendix A – Hoge Raad: Project Hierarchy Organogram

AA.1 Consortium Contractual Structures

Client: Kingdom of The Netherlands

DBFMO contract

Special Purpose Company (SPC)

POORT van
DEN HAAG

100% shareholder: BAM PPP PGMG infra

100% shareholder: BAM PPP PGMG infra

User: Supreme Court of The Netherlands

Delegated Commissioner: Government Building Agency

Government Architect

andri Rijkbouwmeester

Local Authority

External financiers

D&B contract

M&O contract

Engineering, Procurement & Construction (EPC)

Special Purpose Company (SPC)

Interface contract

Measured Term Contract (MTC)

Measured Term Contract (MTC)

ARUP KAAN dGmR

ISS
Orchestra or Improvise: How to Conduct a DBFMO Design Competition?
Orchestrate or Improvise: How to Conduct a DBFMO Design Competition?

**PLANNING**
- Environmental risks
- Discipline risk analysis
- Environmental risk assessment
- Stability frame
- Structure
- Roof and facade SD
- Building security assessment
- Speedline mainentrance
- Safety anti ram raids
- Integral entrance design

**FINANCABILITY**
- Constructability analysis
- Engineerability of the building
- Analysis rebate mechanisms
- Expenses forcing the price up
- Price formulation

**FIRE SAFETY**
- Integral plan fire safety
- Fire escape plan
- Fire safety facade/interior finishes

**STRUCTURAL**
- Stability frame
- Structure in maintenance

**FAÇADE**
- Roof and facade SD
- Building security assessment
- Speedline mainentrance
- Safety anti ram raids
- Integral entrance design

**SECURITY**

**CONSORTIUM**

**HOGE RAAD:**
OPEN TRANSPARENT FACADE

DESIGN PROCESS