In search of an Systems Engineering application for Real Estate Procurement.

Evaluation of requirements management process in DBFMO-projects of the Rijksgebouwendienst

Graduation thesis report
# Colophon

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Preface

This report is the result of 12 months of research I performed for my master graduation. In this research I applied the knowledge obtained in around seven years of education at the faculty of TPM at Delft University of Technology. The research project is performed within the organisation of the Rijksgebouwendienst in The Hague and with this graduation report I finish my master’s study, namely Systems Engineering, Policy Analysis and Management in which I have selected the specialisation on Land Use & Development.

The performance of this graduation phases was characterized by a magnitude of ups and downs which all have contributed to my own personal development. What initially began with a slight interest in Public-Private Partnerships in the real estate sector in the Netherlands; the love for application of consolidated research methodologies; and little knowledge on the Systems Engineering methodology resulted in an extensive research into the performance of the requirements management process performed in DBFMO project for the identification of stakeholders requirements which is used as input for the definition of the performance requirements in the Output-Specification document. What interested me right away was the potential of Systems Engineering for this process and how this could be used as a methodology for the definition of DBFMO projects. I can imagine that this framework – when the Rijksgebouwendienst invests significantly in the development of this Systems Engineering for their project management practice – can be of added value for the entire life-cycle of their projects. At the same time I perceived this application in the current definition process of DBFMO projects as the major challenge of this graduation process as I have a very limited knowledge-base on the practical performance and application of SE projects – as with performance of qualitative research as a case-study – so this significantly enriched my knowledge-base on the performance of DBFMO-projects; the position and substance of an Output-Specification; and the application and development – or the difficult of this – of Systems Engineering. More personally I highly value the lessons I learned by being part of the Directie Projecten of the Rijksgebouwendienst. The most of the time-delay was caused by the fact I was active in multiple projects of the Rijksgebouwendienst – for example the performance of risk management sessions for the procurement of DBFMO projects – and this provided me with valuable practical and social experiences.

At the first place I would like to thank Martin de Jong and Ad Straub for the discussions on the contents of my research; for their patience; and for their interest in my personal development as part of my graduation. Also I would like to thanks Jan Mutsaers and Diederik van der Staay for their practical support; lengthy discussion on the practical substance of my research; and their enthusiasm. Third, I would like to thank Ernst ten Heuvelhof for his insights and guidance. Finally, I would like to thanks Frank van Herwijnen as he enabled my graduation internship at the Rijksgebouwendienst.

Ronald den Hoed

Dordrecht, January 2014
Executive Summary

There is a growing recognition that the requirements management process is regarded as a factor which significantly influences the performance of construction projects. This process is frequently performed by the Rijksgebouwendienst in their DBFMO-projects (Design, Build, Finance, Maintain and Operation) to gain insight on the objectives; goals; constraints and requirements towards the top-level system definition derived from the projects environment and the influenced stakeholders. The integral character of the DBFMO-contract (as a PPP mode of procurement) requires this Dutch governmental housing agency to define the requirements on the real estate and related facilities in an early stage of the project. By means of performance-based briefing the identified top-level system requirements are translated in performance specification and documented in the Output-Specification document. As the qualitative performance of this process is frequently questioned, multiple academics works are performed to improve the current practice but a applicable framework is lacking to overcome the identified limitations. In addition, knowledge on this process is mainly based on studies on traditional procurement projects and insights from PPP-projects are limited. An framework which is identified to be able to overcome the limitations in the current practice is the Systems Engineering framework which provides an holistic approach for project management of projects in complex environments. The Rijksgebouwendienst have acknowledged the relevance of this framework and wants to integrate its concepts in their project management paradigm but its development is lacking.

The objective of this graduation research project is to contribute to the performance of the current requirements management practice by (1) evaluation of the current practice in DBFMO-project of the Rijksgebouwendienst; and (2) by an assessment of the relevance of the integration of SE in the current requirements management practice of the Rijksgebouwendienst. The main research question therefore is framed as: “How can the current performance of the requirements management process of DBFMO-projects by the Rijksgebouwendienst be improved by the integration of the Systems Engineering framework?” To address this question multiple steps are performed with the aim to evaluate the current requirements management process and to couple the relevant SE elements by means of the formulation of a normative SE model.

The research starts with a literature study performed to formulate the theoretical framework required for the achievement of the objective of this research. This theoretical framework is comprised of a conceptual model on variables influencing the performance of the requirements management process; and of an theoretical discussion and selection of relevant SE elements based on the substance of the requirements management process. Firstly, a conceptual model is designed in which variables are integrated which are perceived to have a relevant influence on the performance of the requirements management process. Six variables are identified – Experience of team with process; Commitment and Resistance of stakeholders; Roles of stakeholders; Consideration of multiple perspectives; Methods used for collection of information; and Knowledge on formal procedures of process – and are used to formulate propositions which reflect their expected theoretical relation towards the performance of the requirements management process. These variables and propositions are used in an case study on 3 projects of the Rijksgebouwendienst as a theoretical perspective to evaluate the current
performance of the process in the definition phase of a DBFMO projects. The theoretical framework is completed by means of selection the Problem Definition and Requirements Analysis as relevant SE phases which can be used in the formulation of the normative SE model for the process$^1$.

The main contribution of this research project is that insight is provided in the performance of the requirements management process in the context of DBFMO-projects and that it is indicated how the integration of the SE framework in the project management paradigm of the Rijksgebouwendienst can overcome/manage shortcomings and weaknesses identified for this process. Before this research descriptions and definition on variables influencing the performance of the requirements management process were available, however they were perceived to be derived from studies performed in the context of traditional procurement projects. By reflecting this knowledge on the performance of the process performed by the Rijksgebouwendienst, the research not only provides valuable insight for the Rijksgebouwendienst on their performance of this process, but it also provide relevant knowledge and insights on the identified variables in the context of a DBFMO-project. This provides an initial scientific relevance as this knowledge was before the start of this project only limitedly available.

Aside from this knowledge, the formulation and discussion of the normative SE model provides valuable insights for delegates of the Rijksgebouwendienst who already have a positive perception towards the integration of this framework. It is observed during the internship that the perspective on the use of SE in the project management of the Rijksgebouwendienst differentiates from very positive to very negative. On what assumptions these two perspective are based is not relevant at this point, but what is that the assessment of the relevance and normative application of SE provide arguments for the initiation of further research on this framework.

**Keywords:** Requirements management process – Public-Private Partnerships – Systems Engineering – Performance-based briefing – DBFMO

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$^1$ Based on life-cycle description of Department of Defense (2001)
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1. Introduction

1.1 DBFMO projects of the Rijksgebouwendienst

There is a growing recognition that the requirements management process\(^2\) or client briefing is regarded as a factor which significantly influences the performance of construction projects.\(^3\) One public actor which has a significant role in the Dutch real estate sector and frequently performs this process is the Rijksgebouwendienst. This is the Dutch governmental buildings agency commissioned with the national corporate real estate management. Around 2,000 objects are managed by this organisation which has the responsibility to make sure that the quality of the asset portfolio matches the demands and needs of their clients.\(^4\) A relatively new means in their procurement strategy is the use of the integrated contract form of DBFMO which is perceived as a mode of Public-Private Partnership (PPP) in which the various components of project delivery – Design, Build, Finance, Maintain and Operation – are bundled and transferred to the private sector\(^5\). This integration provides a promising way for the optimization of the project realization and management as it creates significant commitment among the different actors involved\(^6\) (Straub et al, 2012).

The integral character of the DBFMO-contract requires the Rijksgebouwendienst to define the requirements on the real estate and related facilities in an early stage of the project. This is defined by means of performance-based briefing, which means that requirements are formulated in the form of performance specifications and service level agreements, often in combination with minimal technical requirements (Leiringer, 2006). These are documented in the Output-Specification (OS) document\(^7\) which indicates what is expected to be delivered by the private consortium. In comparison with traditional projects the use of performance specifications means that the private contractor is asked to deliver a certain quality and function instead of prescribing precisely how this is to be realized. The use of performance based briefing and the integral character of the contract are claimed to enable the private actor to be innovative and use their knowledge to create solutions that best serve the client’s need (Li & Akintoye, 2003).

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\(^2\) In this work referred to as the requirements management process. Also framed as the client requirements management process, briefing process or client briefing.

\(^3\) For reference, see for example (Barret & Stanley, Better construction briefing, 1999; Chan, Scott, & Lam, 2002; Chan & Chan, 2004; Emes, Smith, & Marjanovic-Halburg, 2012).

\(^4\) The policy of the Dutch government is defined in such a way that real estate management of Dutch governmental organisations is managed by the Rijksgebouwendienst.

\(^5\) Discussion on the procurement mode of DBFMO and the use of this in the Dutch government can be found in (Delmon, 2011; Rijksgebouwendienst, 2011; Nijhof, 2011; Ministerie van Financien, 2011)

\(^6\) This is one example of an positive effect of the use of PPP modes as DBFMO. This mode of procurement is claimed to increase the efficiency of the project performance; increases the incentives for on-time delivery; increase of 'Value for Money.'

\(^7\) Mostly a digital relational database is used in which the performance specifications are integrated.
1.2 Requirements management process in DBFMO projects

The performance specifications are the product of the requirements management process in which the Rijksgebouwendienst aims to create a clear understanding of the requirements; goals and objectives of their public clients. This process is defined by Yu et al. (2010) as the systematic approach that identifies/manipulates all project requirements by means of defining, eliciting, analysing, translating, organizing and documenting requirements before integrating them in the project description. Multiple scholars indicate this process to be a critical element for the successful delivery of construction projects and problems in realized real estate can often be traced back to the inadequate management of this process. In order to achieve a satisfactory result it is essential that a proper process is managed to achieve full acquisition of knowledge on client’s aspirations which appear in both tangible and intangible form (Yu, Chan, Chan, Lam, & Tang, 2010).

In order to safeguard this qualitative performance and quality of their DBFMO projects the Rijksgebouwendienst has formulated the goal to create a quality management system which safeguards the process and substance of the DBFMO projects. Despite the efforts a structured methodology for the performance of the requirements management process is lacking or inadequate. The Rijksgebouwendienst acknowledges this and states that it has become of significant importance to develop a structured method to ensure quality of the information input for the formulation of the OS document. Therefore, the critical analysis and evaluation of the current requirements management practice in DBFMO projects is perceived to be relevant as the starting point of this graduation project because “especially for PPP-projects, with a long contract period, it is important that the client will recognize his input and has faith in the outcome and its flexibility over time. If the client is suspicious and/or dissatisfied, it is very hard to create a real partnership during the rest of the contract.” (Zeegers en Ang, 2007) This is achieved by the performance of a ‘qualitative’ requirements management process which produces the information that enhances understanding of what the stakeholder’s desire towards the product of the project.

Despite the acknowledgement of the significance of this process there still is limited theoretical knowledge available on requirements management performed in DBFMO projects or other PPP forms. Yu et al. (2010) performed a research on the limitations of this process in D&B projects and indicate that the current practice yields numerous limitations. These relate to incomplete and inconsistent requirements and specifications due to incomplete information on stakeholders requirements; misunderstanding and misinterpretation of requirements; inadequate time allocated for the briefing process; lack of (or inadequate) end-user or client involvement in the process; failure to manage end-user expectations; lack of flexibility of requirements. The need for evaluation of specific PPP processes is acknowledged by Hodge, Greve and Boardman (2010) by

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8 In case of DBFMO project the project description is defined in the OS document.
9 Derived from (Shen, Li, Chung, & Hui, 2004; Lam, Chan, & Chan, 2008; Ahmad, Adnan, Bari, & Adb Rashid, 2011).
10 Client refers to the clients of the Rijksgebouwendienst. Which are Dutch governmental organisations – sometimes also non-governmental organisations – for which the Rijksgebouwendienst manages the procurement of the real estate projects.
11 Derived from (Kamara, Anumba, & Evbuomwan, 2002; Kamara, Anumba, & Evbuomwan, 2000; Miron, Leite, & Formoso, 2005).
12 The relevance of the object of study is perceived from an academic as the perspective of the Rijksgebouwendienst.
13 These limitations are also indicated in the process of traditional procurement projects. The work of Yu et al (2010) is one study which focusses on this process in D&B projects where the most attention is given to traditional procurement project.
stating that “no (national) government has performed normatively appropriate analysis of PPPs”. They express the need for empirical studies on performance of PPP projects. By means of evaluation of the current performance of this process this research project aims to provide a basis for the development of a structured and qualitative requirements management process performed by the Rijksgebouwendienst and contribute to the limited theoretical knowledge on this process in the context of DBFMO/PPP projects.

1.3 Systems Engineering for definition of DBFMO projects

Multiple initiatives have preceded this research project which assessed the requirements management process in construction projects\textsuperscript{14}. However, a practical and applicable framework is needed to improve the current practice (Yu, Chan, Chan, Lam, & Tang, 2010). From an academic perspective there is a need to create insight in the requirements management process performed in integrated contract and PPP as only limited attention has been provided to this process. This is in line with the practical shortcomings of the current practice as indicated by the perspective of the Rijksgebouwendienst. A framework which is perceived to be of potential added value for the requirements management process and the formulation of the performance-based briefing is the Systems Engineering (SE) framework. This is perceived by the academic world and the Rijksgebouwendienst to be a framework which can help the definition, procurement and management of construction projects over its life-cycles and therefore relevant for the integration and application in the current project management practice of construction projects\textsuperscript{15}.

Primarily developed by the military industries as a framework which was used to design and manage large engineering projects, the SE framework is developed as a structured method towards specification, design, acquisition, integration, reengineering, and implementation of a complex system over its life cycle (Yahiaoui, Sahraoui, Hensen, & Brouwer, 2006). The potential value of SE for construction is starting to be recognized but the industry has been slow to adopt the principles of SE advocated by practitioners and academics (Emes, Smith, & Marjanovic-Halburg, 2012). The Rijksgebouwendienst indicate that the use of SE is perceived to be a positive contribution for the procurement and management of their projects over the whole life cycle and the management team aims to develop this principle in the long-run to be used in the development, procurement and management.\textsuperscript{16} However, it is observed and stated by delegates that they don’t have the capacity to develop this concept and therefore an applicable SE framework which can be used in the definition of their projects – including DBFMO – is still lacking. This research incorporates these perspectives and aims to create insight in the relevance and added value of the SE framework for the integration in the requirements management process of DBFMO projects.

\textsuperscript{14} See for example (Ang, Wyatt, & Hermans, 2001; Arayici, Ahmed, & Aouad, 2006; Cheong, Anumba, Hill, & Bouchlaghem, 2003; Kamara, Anumba, & Evbuomwan, 2000).
\textsuperscript{15} For reference, see for example (Emes, Smith, & Marjanovic-Halburg, 2012; Yahiaoui, Sahraoui, Hensen, & Brouwer, 2006; Fernie, Green, & Weller, 2003).
\textsuperscript{16} Both traditional works projects, integrated contracts and PPP projects as DBFMO.
1.4 Scope and research questions of research project

The scope of this graduation project is confined to the current requirements management process performed in DBFMO projects by the Rijksgebouwendienst. This delineated the process in which the Rijksgebouwendienst interacts with their clients in order to provide functional input for the formulation of the output-specification document. The goal of this research is to create a clear perspective on the strengths and weaknesses in the current performance of this process. As this research goal mainly focusses on the process performed to collect, analyse, translate and document the requirements of the set of stakeholders towards the DBFMO real estate project, the formulation of the actual specific performance requirements is integrated in the periphery of the delineation and not forms the main focus. The assessment of the requirements management process is based on knowledge derived from the relevant academic field which provides statements on how this process is perceived to be performed or which variables are important in this process from a theoretical perspective.

By means of the SE framework this research project aims to create insight in the level of its relevance and applicability to overcome the indicated shortcomings and weaknesses in the current requirements management practice. The full implementation of this framework shall not be the focus of this research project since the rationale for development and adoption of the SE framework by the construction sector and the Rijksgebouwendienst is related to the evaluation of the context where it is to be integrated. As is indicated by Fernie, Green & Weller (2003), central to the understanding of the applicability of SE in construction procurement practices is an appreciation of the way practice is shaped by its context. They urge the need to gain knowledge how the context of the requirements management process in construction projects influences the applicability of SE and perceive this as a relevant first step. Therefore, this research provides insight in the relevance and added value the SE framework is expected to have for the application in the requirements management and definition process of DBFMO projects. This entails the indication of its contribution as a description of a normative model which indicates how the relevant SE elements ought to be used in the current requirements management process. This step forms the first step in the design of an applicable SE framework for the definition of the OS document. This knowledge is used to formulate the main research questions of this work which is:

\[
\text{How can the current performance of the requirements management process of DBFMO-projects by the Rijksgebouwendienst be improved by the integration of the Systems Engineering framework?}
\]

To be able to answer this main question this work must address multiple elements related to the requirements management process in DBFMO projects. Therefore, the following sub research questions are formulated:

\text{Research Question 1 = How can the context be described in which the requirements management process is performed in DBFMO projects of the Rijksgebouwendienst?}

\[\text{On the long-run it is perceived that the SE framework can be used for the whole life cycle of projects of the Rijksgebouwendienst. However, in this early stage of the development of the framework only the relevance of the significant elements and their application can be discussed.}\]
Research Question 2 = Which theoretical framework can be used which indicate the predicted performance of the process and indicate the normative elements of SE to enable the assessment of the current requirements management performed in DBFMO projects by the Rijksgebouwendienst?

Research Question 3 = How can the performance of the requirements management process in DBFMO projects of the Rijksgebouwendienst be evaluated in terms of the theoretical framework?

Research Question 4 = Does the SE framework provide relevant elements which can be used to overcome the current weaknesses and shortcoming in the performance of the requirements management process of DBFMO projects of the Rijksgebouwendienst?

1.5 Structure of thesis

Chapter 2 introduces the research problem more extensively and gives a more detailed description of the research that is conducted. Chapter 3 answers RQ 1 and describes the context in which the requirements management process is performed. Chapter 4 answers RQ 2 and discusses the theoretical framework which is used for the evaluation of the requirements management process performed in the DBFMO projects. Chapter 5 answers RQ 3 by presenting and discussing the findings of the case study which incorporates the presentation of a SWOT analysis on for the performance of the current requirements management practice. Chapter 6 uses the knowledge derived from this case study and discusses how elements of the Systems Engineering framework can be used in the current performance of the requirements management process and definition of the output-specification. This chapter therefore provides answer to RQ 4. Chapter 7 presents the Conclusion and Recommendations of this graduation project.
Part I

Design of Research
2. Research method

As with all reasonable and qualitative research projects, a decent front-end planning is required to prevent producing a random “mass of descriptive material waiting for a theory, or a fire” as stated by Ronald Coase (1988). Therefore, we acknowledge the importance of a clear delineation of the research and the steps that are required preceding the formulation of findings. This chapter presents the research method used in the research project. This research method consists of the research logic which is discussed in paragraph 2.1. Paragraph 2.2 provides the discussion for the selection of the research method used in this work – the case study approach. Paragraph 2.3 discusses the case selection procedure for the case study. Paragraph 2.4 discusses the data collection protocol used and paragraph 2.5 shortly discusses the approach used for analysis of the empirical data collected by this case study.

2.1 Research logic

Figure 1 gives an overview of the steps taken to provide an answer to the research questions.

*Step 1 and Step 3 are performed in order to formulate the theoretical framework which is used during the assessment of the empirical data. Firstly, a literature study is performed on the state-of-the-art knowledge on the requirements management process in construction projects. The goal of the literature study is to be able to*
formulate a conceptual model which presents the most important variables and their relation to the “qualitative” performance of the requirements management process. This provides the predicted framework which forms the basis for the assessment of the empirical data which gives rise of the observed pattern. Step 3 is used to gain insight in the SE framework and elements which are perceived as relevant for the integration in the requirements management process.

Step 2 is performed in order to gain insight in the contextual characteristics provided by the Rijksgebouwendienst and the DBFMO construction projects. When assessing the relevance and possibility of integration of the SE framework this context can be used as it is the context which defines the mode of applicability (Fernie, Green, & Weller, 2003).

Step 4a represents the assessment of the empirical data by means theoretical framework and its propositions formulated in the first step. During the case study we gained knowledge on the relevance of the variables identified in the academic literature and their relation to each other and the performance of the process. This step makes it possible to assess the propositions in the context of PPP projects since the model is mainly based on knowledge derived from traditional procurement projects. In addition, it can be expected that new insight can be provided in relation to the theoretical description of requirements management in PPP construction projects. From a practical perspective this step gives an indication of the strengths, weaknesses, opportunities and threats of the current performance of the process by the Rijksgebouwendienst based on the assessment of three cases in the case study. This enables the formulation of strategies and actions the Rijksgebouwendienst can undertake on different levels to safeguard and improve the qualitative performance of the requirements management process. The SWOT-methodology is used in this step as a format for this practical assessment.

Finally, in Step 4b the empirical knowledge and output of the SWOT-analysis is used to assess the relevance of the SE elements by reflecting the current performance on the selected elements. This provides basis for the assessment of the relevance of the framework and this knowledge is used to further define an initial normative application of the SE elements in the requirements management process by the Rijksgebouwendienst.

2.2 Selection of case study in research

2.2.1 Knowledge required on performance requirements management process

The suitability of the research method is determined by the research problem at hand (Leiringer, 2003). Each of the different research methods provides an alternate method of processing data. However, the research method should be selected on its ability to contribute to the answering of the research questions and objective of the research (Leiringer, 2003; Yin, 2003; Wing, Raftery, & Walker, 1998). For this research project knowledge is desired on the current performance of the requirements management process in DBFMO projects. This requires a research method that provides distinct advantage in answering of an “how” question.

2.2.2 Evaluating social science research choices
2. Research method

By means of comparison of four prominent research methods this section aims to provide a clear argumentation for the selection of the research method used. The research methods that are used for this comparison are not all of the alternatives available but are expected to be relevant for this type of research. The following qualitative research methods are used for this selection procedure:\(^{18}\):

- Case study
- Surveys
- Experiment
- Archival research

The full evaluation of these research methods is presented in Appendix A. Based on this evaluation the case study method is presumed to be most suitable for this research project. This method provides the opportunity to investigate the requirements management process in different projects. Using only an archival research will create some risks due to the high dependency of the availability of documentation of the object of study. Conducting an experiment will not suit the goal of the research due to the lengthy time characteristic of this specific process. And finally, a survey is not suitable at this moment due to the fact that this research method is mostly used to explain the relations between a numbers of variables.

2.2.3 Requirements of a case study research.

To meet the main criticisms of the case study approach Eisenhardt (1989) and Yin (2003) suggest that two major requirements need to be fulfilled. These relate to the fact that the case study has to be theoretically grounded and a case study research should integrate a research design. The first requirement means that a priori knowledge and explanation on the research object is required. This requirement is met in this case study by the formulation of the theoretical framework presented Chapter Four. The latter requirement means that a research design should be created to integrate predetermined procedure of investigation. This design should incorporate the formulation of research questions; unit of analysis; data analysis procedure & logic of replication. The research questions are already presented in the introduction of this work. The latter elements are presented in Appendix B as they provide mainly a theoretical perspective on the performance of the case study. This perspective and knowledge is used as guidance and structure for performance of the case study.

2.2.4 Use of case study in this research project

Yin (2003) distinguishes three types of case studies, namely explanatory, exploratory and descriptive. For this research project the concept of a descriptive case study is used as it can be used to describe a phenomenon and enables the researcher to assess this phenomenon with a theoretical framework or propositions. The knowledge on this case study is used in this work to design the research as is discussed in Appendix B. To get insight in the performance of the requirements management process a theoretical framework is formulated in which – by means of an conceptual model – variables are identified which are perceived to significantly

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\(^{18}\) Research methods are derived from the work of Yin (2003).
influence the performance of the process. Propositions are based on these variables and their position in the conceptual model and the case study provides the opportunity to test and reflect upon these propositions thereby creating insight in the current performance of the process. This framework also integrates a first description of the SE framework and its elements to assess its relevance and gain insight in how this process could be expanded with the use of this methodology. To get a good understanding of the object of study it is perceived to be of added value to assess multiple DBFMO projects in which this process is performed. This increases the amount of knowledge on how the requirements management process is performed over these different projects with different characteristics.

2.3 Selection of cases

2.3.1 Case selection procedure

There is no single approach to perform the selection of cases of a case study (Leiringer, 2003; Yin, 2003). Based on the object of study a set of selection criteria is created to perform a screening of the portfolio of the Rijksgebouwendienst. An important concept in this screening process is the fact that the selected cases must be significantly different from each other. This is based on the work of Pettigrew (1988) who noted that because the limited availability of cases available for research the cases should be selected based on “extreme” situations and polar types in which the object of study is “transparently observable”. The extreme situations means that the cases selected must integrate different characteristics so that they integrate all different elements relevant for the research goals and knowledge is derived on the requirements management process from significantly different contexts. Based on these findings the following selection criteria are formulated which are used in the screening of the DBFMO-projects of the Rijksgebouwendienst:

1. Completion of tender
2. Differentiation in type of project
3. Different client/end-users
4. Requirements management process performed in a different time frame

Based on an extensive literature study on literature on the performance of this specific requirements management process.
2. Research method

2.3.2 Selection of cases

By means of this selection procedure the DBFMO-projects of the Rijksgebouwendienst are assessed to selected three cases which are the primary object of study. For this selection only a limited number of DBFMO projects are available and these are presented in the table 1.

<table>
<thead>
<tr>
<th>DBFMO project</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korte Voorhout 7 – Den Haag</td>
<td>In exploitation</td>
</tr>
<tr>
<td>Belastingdienst – Doetichem</td>
<td>In exploitation</td>
</tr>
<tr>
<td>DUO/Belastingdienst – Groningen</td>
<td>In exploitation</td>
</tr>
<tr>
<td>Pl Zaanstad</td>
<td>Finished tender</td>
</tr>
<tr>
<td>Defensiemuseum – Soesterberg</td>
<td>Finished tender</td>
</tr>
<tr>
<td>Hoge Raad der Nederlanden – Den Haag</td>
<td>Finished tender</td>
</tr>
<tr>
<td>Renovation Rijnstraat 8 – Den Haag</td>
<td>In tender phase</td>
</tr>
<tr>
<td>RIVM – Utrecht</td>
<td>In tender phase</td>
</tr>
<tr>
<td>Courthouse Breda</td>
<td>In tender phase</td>
</tr>
<tr>
<td>Rijkskantoor de Knoop – Utrecht</td>
<td>Tender preparation</td>
</tr>
<tr>
<td>Bezuidenhoutseweg 30 – Den Haag</td>
<td>Tender preparation</td>
</tr>
</tbody>
</table>

Based on the first criteria the last five projects were eliminated from the group of potential cases. In these projects the tender phase is not completed so these could not be used as an object of study for this research projects. The other projects were assessed on their suitability for the research project and resulted in the selection of three cases:

A. Defensiemuseum
B. Hoge Raad der Nederlanden
C. DUO/Belastingdienst

To provide insight in the assessment of the selected cases for the case study, table 2 gives a presentation of the assessment of these selected DBFMO project based on the four criteria formulated in the selection procedure.

<table>
<thead>
<tr>
<th>DBFMO project</th>
<th>Criteria 1</th>
<th>Criteria 2</th>
<th>Criteria 3</th>
<th>Criteria 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defensiemuseum</td>
<td>Yes</td>
<td>Museum</td>
<td>Ministry of Defence Two museums</td>
<td>2010</td>
</tr>
<tr>
<td>Hoge Raad</td>
<td>Yes</td>
<td>Court house + Offices</td>
<td>Ministry of Safety &amp; Justice PDH Hoge Raad</td>
<td>2011</td>
</tr>
<tr>
<td>DUO/Belastingdienst</td>
<td>Yes</td>
<td>Offices + Specialties</td>
<td>DUO Belastingdienst</td>
<td>2007</td>
</tr>
</tbody>
</table>

2.4 Data collection in case study

2.4.1 Data collection procedure

Case studies are characterized by the fact that they typically combine data collection methods such as archival research, interviews, questionnaires and observations (Eisenhardt, 1989). This research project is mainly based on the information collected by interviews performed in the context of the selected projects. These interviews
are performed to create insight in the knowledge of the experts on the requirements management process performed in the DBFMO projects in relation to the theoretical framework which is used as an perspective in this assessment. Two types of interviews are used for the data collection. Initially, unstructured interviews are conducted with key respondents within the Rijksgebouwendienst related to the requirements management process to create a clear perspective on this process and to perform an initial comparison of the academic literature with the process performed in practice. Semi-structured interviews are then used to obtain information related to the theoretical framework and the requirements management the respondents performed, managed or participated in. The interviews are performed with respondents which were active in the requirements management process of the selected DBFMO projects. Next to the interviews performed within the selected cases, an additional amount of interviews are conducted within the context of other DBFMO projects. This enables the reflection of the findings of the three central cases on outlying projects which thereby enriches and -- partially -- validates these findings. We aimed to conduct interviews with respondents from the different stakeholders\textsuperscript{20} and from different levels in the project organization. This differentiation in respondents must increase the validity of the data collected related to the DBFMO projects. Readers who are interested in the selection of the respondents and the information of these respondents, Appendix C presents a discussion on these subjects. In addition to the interviews the empirical dataset also integrates information derived from archival data and observations.\textsuperscript{21} According to Van Maanen (1988) observations are a stream-of-consciousness commentary about the phenomenon which is object of study, integrating both observation and analysis. Using the two types of data sources complemented with the data derived from the interviews made increases the possibility of the triangulation of data\textsuperscript{22}.

### 2.4.2 Interview protocol

In order to increase the ‘quality’ and reliability of the empirical data, an interview protocol is formulated. An interview protocol is perceived as a standardized approach for each of the interviews which provide a guide for the interviewer in the process but it also integrates the overall processing of the interviews. The overall interview protocol in this research project is based on the approach presented in the work of Yu et al. (2010):

- Initial contact with respondents using information mail
- Providing topic list and detailed information on research after approval of interview (Appendix D)
- In-depth face-to-face interviews, which were audio-recorded
- Writing of draft report of interview by using recordings
- Solicitation of comments and feedback from respondents on draft report
- Adaptation of comments in report and final confirmation of interview report by respondent

\textsuperscript{20} Interviews are conducted with respondents from the different stakeholders participating in the requirements management process. These are from the organisation of the Rijksgebouwendienst as well as their clients.

\textsuperscript{21} I was present for over seven month within the Rijksgebouwendienst and participated in a number of side projects and activities aside from my graduation course. However, during these activities I observed and made notes which I used as input for the case study research.

\textsuperscript{22} However limited as the primary source of information was found to be the use of interviews and only limited use was found in the archival data.
The final two steps are integrated to increase the validity of the empirical data. Respondents are asked to read the draft report – which closely relates to a full transcription of the interview – and to write down their comments, feedback or adaptations. These are then integrated in the final report of the interview. The series of interviews were undertaken in the spring/summer of 2013. Each interview took 1-2 hours and it was assured with the respondents that all the project information and opinions acquired will only be used for this research. In addition, the names of the respondents will not be disclosed to any party due to personal privacy and confidentiality signed by the researcher. The interviews reports are only provided to the graduation committee of the researcher by means of the interviews presented in the Interview Book.

2.5 Approach for analysis of empirical data

The formulation of findings in a research project requires a systematic understanding of the cases by means of a logical chain of evidence and maintaining theoretical coherence (Miles & Huberman, 1984). This chapter introduced – research design & case study design – the pattern matching between the cases as mode of analysis used in this research project as the basis of this systematic understanding of the practical performance of the requirements management process. The theoretical coherence is safeguarded by formulation of a theoretical framework in which propositions indicate the predicted relation of variables to the performance of the process. These propositions and variables are defined in the theoretical framework presented in Chapter 4. In Chapter Five, these predicted relations and defined variables are compared to the observed pattern in the DBFMO projects. The variables and their predicted relation to the performance of the process are used as an initial perspective in the empirical discussion since the academic knowledge on this process is limited in its application for PPP and DBFMO projects and this research aims to expand this knowledge for the performance-based briefing. By the use of the within-case and cross-case analysis in which the empirical data is assessed per variable and proposition the analysis is structured to increase the quality of this analysis. This data analysis procedure is further discussed in Appendix B.

2.6 Conclusions

To evaluate the relevance of the SE methodology for integration in the definition process of DBFMO-projects knowledge is required on the theoretical knowledge on the requirements management process; the substance of the SE methodology; and the current performance of the requirements management process. To increase the knowledge on the current requirements management practice performed by the Rijksgebouwendienst – structural or non-structural – this research presents the findings of a performed case study. This chapter provides argument for the selection of this research methodology, as it is not chosen at forehand but it is perceived most appropriate in fulfilling the objectives and provides the required knowledge. Three DBFMO-projects are selected of which respondents are interviewed. This empirical data provides the basis for the evaluation of the requirements management process. By means of a within-case and cross-case analysis with use of a theoretical framework which identifies six significant variables to influence this process this research aims to enable a qualitative assessment.
“In seeking to transfer SE practices from one sector to another, it is important to understand the contextual differences.” This context needs to be considered in this research projects when the Rijksgebouwendienst aims to implement the SE methodology in the procurement of DBFMO projects. In order to increase the knowledge on the context this chapter aims to discuss the organisation of the Rijksgebouwendienst, the performance of DBFMO projects from a process-perspective and the performance based briefing in the Output-Specification document. This provides an answer on the first research question:

**Research Question 1** = How can the context be described in which the requirements management process is performed in DBFMO projects of the Rijksgebouwendienst?

The discussion of this context starts with a short introduction of the Rijksgebouwendienst and its organisational structure in paragraph 3.1. Paragraph 3.2 discusses the origin and use of DBFMO contract and the process performed which relate to the requirements management and formulation of the OS document. Paragraph 3.3 describes the performance based briefing approach used in DBFMO projects and the use of the Nordic Five-level structure. The final paragraph, paragraph 3.4, presents a discussion on the position of the OS document in a DBFMO contract and the digital model used by the Rijksgebouwendienst to document its substance.

### 3.1 Introduction of the Rijksgebouwendienst

The Rijksgebouwendienst is a department of the Ministry of the Interior and Kingdom Relations and is the Dutch governmental housing agency. The Rijksgebouwendienst is responsible for the management and development of the real estate portfolio of the Dutch government which is comprised of around 2,000 objects. This entails the management of around 7 million square meters of floor space of which 70% is in the ownership of the Rijksgebouwendienst. Their aim is to “create incentives for the private market to produce high quality and innovative solutions which results in the development of the qualitative service which is provide to the public clients of the Rijksgebouwendienst”.

The organisational structure consists of four directorates of which each have their responsibilities which can be allocated to different processes or phases in the management of projects. The hierarchical organisational structure of the Rijksgebouwendienst is presented figure 2. The organogram identifies the four directorates

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23 Directly derived from (Fernie, Green, & Weller, 2003)
which are referred to as Directies in Dutch. These are Real Estate (in Dutch: Vastgoed), Projects (in Dutch: Projecten), Maintenance (in Dutch: Beheer) and Advice & Architects (in Dutch: Advies & Architects)\textsuperscript{24}.

The **Directie Vastgoed** is responsible for the optimal configuration of the real estate portfolio of the Rijksgebouwendienst. This directorate interacts with governmental organisations\textsuperscript{25} and identifies possible real estate changes and demands at the side of these clients. The initial requirements and the wishes of these clients form the central pillar of this process and are used as constraints for potential real estate project (renovation of newly constructed). In this process four specialities of this directorate are identified, namely portfolio management; asset management; project development and initiation; and management of monuments.

The **Directie Projecten** is responsible for the realisation of projects of the Rijksgebouwendienst which vary from new construction, renovation, and restoration of monuments. Due to the large variation of the project portfolio\textsuperscript{26} the Directie Projecten is responsible for process management and project management of these different projects. This research projects mainly focusses on the processes and activities performed under the responsibility of this directorate as these mainly relate to the requirements management process of DBFMO projects. The processes performed in a DBFMO in relation to the requirements management and formulation of the OS document is discussed in paragraph 3.2.2.

The **Directie Beheer** is responsible for the management of the quality of the real estate in the portfolio of the Rijksgebouwendienst. This means that this directorate is responsible for the maintenance of the real estate buildings and provides knowledge on maintenance subjects in procurement of projects.

The **Directie Advies & Architecten** is responsible for the advice on technical, functional, spatial, architectural and financial elements of in all phases of the real estate project of the Rijksgebouwendienst. This directorate is perceived to be the knowledge centrum of the Rijksgebouwendienst in relation to the construction and performance of real estate projects and works mostly on behalf of other directorates in projects.

\textsuperscript{24} For the remainder of this thesis the Dutch titles of these directorates shall be used as this gives an better reflection on their titles.

\textsuperscript{25} Client of the Rijksgebouwendienst but project owners in DBFMO projects.

\textsuperscript{26} The Directie Projecten performs an average of 1000 project per year.
3.2 DBFMO projects performed by Rijksgebouwendienst

As a result of the parliamentary enquiry related to the *Bouwnijverheid* (2002-2003) there is increased demand in innovative procurement modes by the Dutch government. The focus was directed at the use of PPP projects and this was institutionalized in the period 2004-2005. The ministerial counsel decided that real estate projects with an expected investment more than € 25 million need to be assessed whether the use of a DBFMO project would be suitable (Rijksgebouwendienst, 2009). By means of a PPC analysis an assessment on the added value for money which is obtained by the use of an integrated contract as DBFMO in relation to traditional procurement of the project is performed (Delmon, 2011). When the analysis indicates that the NPV (Net Present Value) cost of the PPP mode is lower than the NPV costs of traditional procurement than the use of DBFMO can be justified.

3.2.1 Integration of responsibilities in DBFMO projects

DBFMO is perceived to be an “complex” contract as result of integrated responsibilities for the private contractor. DBFMO contracts are perceived by the Rijksgebouwendienst to be the ultimate form of a Public-Private Partnership mainly due to the length of the cooperation between them and the private contractor. The difference between traditional procurement and the different integrated works contracts used within the Rijksgebouwendienst relates to the level of integration of the responsibilities Design, Build, Finance, Maintain and Operate as is presented in figure 3.

![Figure 3 - Level of integration of responsibilities in contracts](image)

In traditional procurement project each of these tasks is separately procured except for the financing which is managed by the Rijksgebouwendienst. On the other side of the spectrum, all of these tasks are transferred to

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27 The Directie Advies & Architecten is internally responsible for the qualitative formulation of the OS document, but towards the client/project owners it is the Rijksgebouwendienst as a whole who is held responsible.
one private contractor as the DBFMO contract covers the whole process and integrates all of the responsibilities to the management of the private contractor. This entails the design of the real estate to an operational building with all related services and facilities. Straub et al. (2012) state that the use of DBFMO in projects assumes to produce “better and most likely cheaper building when the consequences of a particular design are thoroughly examined in the early stages of the development process.”

3.2.2 Performance of DBFMO projects

The performance of a DBFMO projects requires the Rijksgebouwendienst to perform a significant preparation phase since the project requirements are to be defined for the duration of the contract. The average duration of this contract is 25 years and it is perceived to be of added value to perform a qualitative preparation phase in which this contract and the – relevant for this research – Output-Specification document are formulated. The following phases – presented in figure 4 – are performed in the context of a DBFMO project perceived from a high abstraction level. The remainder of this paragraph describes the processes performed in a DBFMO project to indicate the position and context of the requirements management process and definition of the OS document.

![Figure 4 - Phases in a DBFMO project](image)

**Initiation phase**

At the start of an DBFMO project the Directie Vastgoed performs initiation by identifying a need or wish from a governmental organisation towards their housing as a potential project. This directorate constantly interacts with these organisations on their housing situation and they assess whether or not the portfolio matches the demands of their clients or if a reconfiguration of the portfolio is required. When it is observed that a potential reconfiguration is required – by means of a renovation or new construction of real estate – a situation assessment will be performed in which the initial client requirements and wishes are analysed to define the initial scope of the project. This will be integrated in an “process proposal” which provides a discussion of the

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28 It is perceived that this is a very narrow definition because DBFMO projects can differ in the level of integration of responsibilities for the private party without changing the frame of DBFMO. The scope of the project, PPC & PSC and definition of client requirements will result in the integration of the services in the contract.

29 At this moment in time (November 2013) there is a discussion active on the integration spectrum of the O in an DBFMO contract. The Minister of Housing and National Service – Minister Blok – have initiated the plan to create an National Cleaning Service (in Dutch: Rijksschoonmaakdienst) which should perform the cleaning tasks which used to be integrated in the scope of an DBFMO contract. As a result the wide of an DBFMO contract is significantly decreased and its future is questioned.

30 The description of the DBFMO process and the details of the activities performed in its phases are mainly on documentation provided by the Rijksgebouwendienst.

31 The DBFMO process is discussed by using a static perspective which assumes a linear performance of process. This provides the reader some perspective on the positions of the process and activities performed over time. However, it is observed in practice that the processes are performed in a parallel nature and the requirements management process is continuously performed over different phases instead of it to be one specific moment in time.
3. Rijksgebouwendienst and DBFMO projects

Scope and substance of the initial project definition by the various directorates who have stated their perspective on the project and how they perceive their role in its performance. Following this process proposal, the responsibility is transferred to the Directie Projecten which yields the further definition and – potential – procurement of the project. At this point, some initial steps of the requirements management process are performed but these are assumed to have only limited influence on the project since it is the full responsibility of the Directie Projecten to further define these client requirements in this process which leads up to the formulation of the OS document. The activities performed under the responsibility of the Directie Projecten in this next phase – defined as the Initiation Phase – are presented in figure 5.32

This phase is perceived to be the first service which the Rijksgebouwendienst performs for its public clients and which is charged33. The goal of this phase is to further define the project scope, project requirements and procurement strategy which are integrated in an advice of the Rijksgebouwendienst to their client on how to proceed with the procurement. The definition of the client requirements relate, in theory, to the process in which the critical processes, initial requirements, objectives and goals of the clients are formulated on a high abstraction level. As this description assumes an stable scope and environment it must be stated that this work acknowledges the environment/system in which this process is performed. Despite this is mostly placed outside of the delineation of this research and assumes stability, the dynamic and external factors influencing this process are addressed in paragraph 3.2.3.

In this phase the project organisation is established and formalized by means of the Project Start Up (PSU). The general structure of the project organisation of DBFMO project is presented in figure 6. The project organisation is highly hierarchical. The Steering Committee (SE) is responsible for the end-result of the DBFMO project, the high level decision-making and formalization of products. The SC takes decision which are from strategic nature and they safeguard the process, progress and scope of the project. This SC is seated by the delegates with the hierarchical functions related to Director-General and is mostly seated by the project owner, Rijksgebouwendienst and the end-users.

32 This overview is based on a project which I performed during the internship at the Rijksgebouwendienst. This project had the goal to update the handbook on Integrated Contracts which mainly discusses the DBFMO procurement mode from an high abstraction level. This level was used in this presentation.
33 This is performed by means of an Offer or Inquiry. In Dutch this is named the “Offertes”. These are estimation of costs or activities which are related to the process which are to be performed in the next step, the hours this approximately will take and the costs per hour.
The Project Team (PT) is responsible for the integration and safeguarding of the requirements, objectives, wishes and demands of the client in the process. The chairman of the PT is the project-director of the project and is complemented by delegates of the Rijksgebouwendienst, clients and end-users. The Output-Specification team (OS team) is responsible for the formulation of the Output-Specification document and is seated by delegates of the Rijksgebouwendienst and its clients which provide the required information for the requirements management process in addition to decision made in preceding processes or in other teams of the project organisation. The OS team is mostly coordinated by an Advies-Verantwoordelijke (AV'er) from the Directie Advies & Architecten which is held internally responsible for the formulation of an qualitative OS document as already mentioned.

**Definition phase**

When the PPC analysis performed in the Initiation Phase identifies the DBFMO procurement as most suitable mode of procurement the further definition of the project is performed in this phase under the responsibility of the member of the Directie Projecten. An overview of the activities performed in this phase is presented in figure 7. An ambition document is formulated which represents the goals, objectives and ambitions are integrated. This provides the private parties knowledge on the goals towards architecture, functions and other elements on a very abstract level. Central in this phase is the formulation of the OS document in which the knowledge of the requirements management process on the objectives, goals, functional specifications and performance requirements are integrated. Not much literature of the Rijksgebouwendienst is available on how this is preferably is performed but for the formulation of the requirements for the OS document it is mostly referred to the Nordic Five-level Structure. This will be discussed in the remainder of this chapter in paragraph 3.3.2.

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34 In some DBFMO projects it is observed that the coordinator of the OS team is a delegate of the client or project owner. This is dependent on the type of client, its experience and role in the project organisation.
3. Rijksgebouwendienst and DBFMO projects

Selection + Dialogue phase

Based on the selection criteria tendering parties are selected which enter the dialogue phase. In this phase the procurement document are used by these private consortia in their designs. The Output-Specification document is used as a central document since this represents the requirements, objectives and performance specification of the public stakeholder to the project. By means of the dialogue phase the procurement documents are discussed and the designs are further refined. This is perceived to fall out of the scope of the requirements management process and therefore the remainder is not discussed. It is, however, of added value to indicate the position of the Output-Specification document in the DBFMO process.

3.2.3 System analysis for requirements management process

As the previous analysis are related to the DBFMO-system, it is acknowledged at this point that one of the most important concerns affecting the professional practice of DBFMOI is that the project management of the Rijksgebouwendienst and Directie Projecten does not deal exclusively with physical real estate objects. As the aim of the projects is to produce a qualitative product, there are stakeholders; technologies; institutions and organizations involved in the environment which influences the performance of the projects and thereby the requirements management process. Therefore, the DBFMO-projects are performed in a complex system in which is characterized to be influenced by political and institutional uncertainty. Figure 8 provides an overview of the external factors influencing the object of study and which are to be managed by the project management performance.
3.3 Performance based briefing in DBFMO projects

3.3.1 Performance-based approach in procurement of DBFMO projects

The use of DBFMO contracts as the mode of procurement requires a long-term cooperation between the Rijksgebouwendienst and private sector. At the core of this PPP contract lays the specification of the performance required of the object and services delivered by the private party. Unlike traditional procured projects or UAV-GC contracts this performance-based approach uses so-called performance specifications which describe a required quality instead of prescribing the realization in detail\(^{35}\). The use of the performance concept started in the 1950s when the National Institute of Standards and Technology developed a performance approach for procurement of government offices (Meacham, Tubs, & Bergeron, 2011). In 1982, after the International Council for Building Research Studies worked on the Performance Concept in Building research, the concept of performance-based briefing was defined as “the practice of thinking and working in terms on ends rather than means. It concerned with what a building is required to do, and not with prescribing how it is to be constructed.” (Gibson, 1982).

Using this performance-based approach has a positive contribution on the control on architectural quality and leaves room for innovations (Fokkema, 2009; Straub, Prins, & Hansen, 2012). A proper and qualitative OS document creates flexibility for the private contractor to find the most cost-effective means of delivering the required output (Lam P., Chan, Akintoye, & Javed, 2011). Despite the advantages of the use of performance based briefing some pitfalls are identified which affect the quality of the outcome of the project if these are not properly managed. The first pitfall relates to the information asymmetry\(^{36}\) of the OS document as it is possible that an OS document is formulated which lacks sufficient precision to cover all service delivery contingencies or elements of the real estate accommodation. This can create unanticipated delivery problems during the dialogue or even realisation phase of the project. In this context, the incompleteness of the contract can result in a lower potential for dispute and abuse which can be disadvantageous for the outcome of the project (Robinson & Scott, 2010). In retrospect, the risks is identified that the OS document is “over-specified” in a sense that an great amount of quality is required from the private consortium which decreases their degrees of freedom. Therefore, it is important to formulate a ‘qualitative’ OS document to prevent this and optimize the cooperation between the public and private sector. The literature indicates that a qualitative OS document is dependent on two factors, namely the performance of the requirements management process and the manner this is documented and provided to the private sector\(^{37}\).

Another concern is related to the optimal attainment of value of PPP projects\(^{38}\). One of the concerns relate to the difficulty in specifying the quality of a service or asset; “Sometimes the precise definition of a high quality service may be elusive, which allows different interpretations and can result in post-contract disputes.”

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\(^{35}\) Derived from Akintoye et al. (2003)
\(^{36}\) Derived from (Robinson & Scott, 2009)
\(^{37}\) Based on multiple sources as (Arayici, Ahmed, & Aouad, 2006; Augenbroe, Malkawi, & de Wilde, 2004; Kamara, Anumba, & Evbuomwan, 2000)
\(^{38}\) Derived from (Robinson & Scott, 2009)
(Akintoye, Hardcastle, Beck, Chinyio, & Asenove, 2003). A possible result is that this ambiguity of performance requirements leads to changes in the contract during the execution of the DBFMO contract (Robinson & Scott, 2009). This leads to an increase of the costs of the project and in a time delay. Therefore, there is a need for concise definition and clarity of the performance requirements integrated in the OS document for the real estate accommodation and the services to be provided and the way these are documented.

### 3.3.2 Nordic Five-level Structure

Central in the formulation of the OS document is the Nordic Five-level Structure which is frequently referred to by delegates of the Rijksgebouwendienst as the mental structure for the formulation and design of the OS document. This is used by the Rijksgebouwendienst during the formulation of the OS document as a guide and structure and its concepts are presented in the pyramid in figure 9.

The approach identifies five layers which provide a mental structure for the formulation of clear performance requirements which can be related to abstractive objectives/goals and functional requirements but also introduces verification methods which can be used to measure the performance of the object on these requirements. From discussion on the structure with multiple delegates of the Rijksgebouwendienst is concluded that it can provide a structure for the formulation of the performance specification, but its application is limited by its highly abstractive level. The approach doesn’t provide any techniques on how the specifications or objectives need to be formulated – and on which level of detail – so this only provides the practitioner insight in the relations of these concepts instead of an applicable methodology of application in the requirements management process.

![Figure 9 - Nordic Five-layer Structure](image-url)
The first layer is used to identify the objectives goals of the client(s) and end-user(s) towards the real estate and services integrated in the scope of the contract. These should, in theory, consist of statements of what the performances requirements are intended to provide and reflect the clients functional input. This input consists of strategic ambitions of the clients which supports support its core business activities in the real estate object. The real estate that is to be created should support the ambitions which the client’s management wants to achieve, in terms of the building as a factor of production.

In the second layer, these objectives and goals are then translated in describing the client’s ambitions, business process, requirements and specific desires in functional requirements. These functional requirements should add value to the core business activities of the users of the building and relate to the initial objectives – goals formulated in the first layer. It is stated in the work of Zeegers & Ang (2003) that the primary measure of value of a workplace is on its functionality. This means that the clients are supposed to clarify its ambitions and its business process in functional terms. A functional requirement is related to the degree to which it can meet the functional needs of the users of the real estate and therefore integrate the required functions of the object.

In the third layer, the functional requirements of the previous layer are “translated” in performance requirements. The reason for this translation of the functional requirements is because they are hard to measure and verify by the Rijksgebouwendienst when the real estate is provided. These performance requirements describe which performance or quality is to be provided by the private party in relation to the functional requirements to allow a proper assessment of the provided real estate and service by the private contractor by means of measurement and verification. Zeegers & Ang (2003) propose two methods of translating these functional requirements in performance requirements – prescriptive method & performance based method – and indicates that the latter approach is more suitable within the concept of performance-based briefing.

### 3.4 Output-Specification document in DBFMO contract

#### 3.4.1 BOM-mechanism

The OS document takes up on important position in the DBFMO contract since a well-drafted OS is fundamental to the successful delivery the real estate and services in PPP projects. Closely related to the performance requirements are the performance monitoring systems and payment systems as the measurement of the level of satisfaction of the provided real estate and services in terms of availability and meeting performance requirements determines the payment due from the public institution (Robinson & Scott, 2009). These three elements – referred to as the BOM-mechanism – provide the primary steering mechanism which the Rijksgebouwendienst use in controlling the quality of the provided real estate and services during the full length of the contract. Figure 10 presents the relations between the three elements. Despite the fact

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39 Description based on Zeegers & Ang (2003); Zeegers & Ang (2007); Fukui, Shirato & Matsui (2005) and on observations made during graduation stage at the Rijksgebouwendienst
40 Based on the Dutch name of the payment mechanism; output-specification and performance monitoring system (in Dutch: Betalingssysteem, Output-specification and Monitoringssysteem)
41 Based on the work of Robinson & Scott (2009)
that we acknowledge the importance of these elements in relation to the OS document, their formulation and substance is not integrated in the scope of this research. This prevents the constitution of an wide scope which cannot be addressed to a sufficient level of detail in the given time for the research project.

The figure shows that the elements each contribute to the provision of the real estate and the services in DBFMO projects. In essence it works in a way that the output-specification prescribes the level of quality, the performance monitoring system measure (by means of agreed measurement systems) the provided qualities of the real estate and services, and this measurement is input for the payment mechanism which determines the level of payment (or penalty) dependent on this provided quality and the availability. This, in theory, creates incentives for the private actor to integrate these requirements in the design (during the design phase) and provide incentives to manage the quality level during the whole life-cycle of the contract.

![Figure 10 – BOM-mechanism](image)

### 3.4.2 Substance of Output-Specification document

In order to increase the level of communicativeness of the Output-Specification document and its substance to the private consortium the Rijksgebouwendienst makes use of a digital model called Relatics\(^\text{42}\). The digital OS model is a relational database in which all of the specifications, objectives, functional and performance requirements are integrated and documented.\(^\text{43}\) The substance of this digital model is mainly based on the conceptual model of the Nordic Five-level structure as it integrates the following elements:

- Goals
- Objectives (in Dutch: uitgangspunten)
- Organisation (activities, users and processes)

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\(^{42}\) This paragraph is fully based on literature provided by the Rijksgebouwendienst and on interviews on the structure of the OS document. Therefore this provides an perspective how the Rijksgebouwendienst perceives the OS document.

\(^{43}\) The Rijksgebouwendienst makes use of a standardized OS model and they state that this is performed in order to increase the quality of the OS documents of projects.
3. Rijksgebouwendienst and DBFMO projects

- Performance specifications / requirements
- Verification & Monitoring

These elements will be elaborated on to complete the readers perception on the OS document and its substance as it is used by the Rijksgebouwendienst.

Goals

Goals are integrated in the OS document as the top-level concepts to indicate when the project owners perceives the project to be an success and are used to give the private consortium an impression of what is expected from them from the project owner in the cooperation. Mostly four or five high-level goals on different subjects give an indication what the project is required to deliver and when the project owners perceives the project as successful. These are mostly extracted from the mission or vision for the project (for example formulated in the Ambition Document) but are too abstract or too vague to be used in the actual measurement of the delivered performance. For one of their most recent DBFMO projects, the Hoge Raad project, the Rijksgebouwendienst formulated five goals on the subjects of Appropriate Architecture, Public and Private Section, Functional Housing, Comfort and Safety of Work- and Residence Environment, and Professional Services. An example of a defined goal in the OS of the Hoge Raad is:

Objectives

Objectives are used to further elaborate the concepts defined in the preceding Goals. These are used to answer the questions: how are the goals to be realized by means of the project? As with the Goals, the Objectives do not represent measurable requirements but the objectives are used to increase the perception of the private consortium on the formulated goals and the required performance and delivery of the project. They are used to elaborate the Goals from the perspectives of User Value, Experience Value, and Future Value. However, it is observed that these perspectives are differently interpreted and used in various DBFMO projects or other perspectives are used to discuss the objectives. An example of a defined objective in the OS of the Hoge Raad is:

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46 Depending on the client and type of project.
47 For this example only the features are discussed since the description of the Objectives is perceived to be an extensive discussion of these features.
**Organisation**

By means of the chapter **Organisation** the Rijksgebouwendienst aims to incorporate a description of the Activities, Users and Business Process in the OS document. This information must be used by the private consortium in their design since the DBFMO project is performed to realize housing for the end-users and their organisation. The element Users describe the employees and people (for example visitors) who will make use of the DBFMO project and shortly describe their main attributes. The elements of Activities and Business Processes are closely related as the latter describe the core business processes which are performed by the organisation and activities are underlying of these business processes.

**Performance Requirements**

The central pillar in the Output-Specification is formed by the Performance Requirements which are based on the preceding Objectives and Goals and represent the performance required by the delivery of the private consortium. They indicate what spaces, functions, services and quality level is expected to be delivered and therefore provides measurable requirements which are central in the BOM mechanisms. The Performance Requirements in an OS document are categorized by different Requirements Trees (*in Dutch: Eisenbomen*) which are developed for different concepts, namely Spaces, Services, Architectural and Urban Quality, Comfort & Sustainability, Safety, and Facilities. At this point, only the Spaces Tree and its relation towards the other elements is discussed, the other remaining elements are further discussed in paragraph

The **Spaces Tree** and its related performance requirements is perceived by the Rijksgebouwendienst as the backbone of the OS document and thereby the performance based briefing of their DBFMO projects. This tree is comprised of the required spaces which are to be delivered by the project and is perceived to be very similar to an Spatial Design Specification (*in Dutch: Ruimtelijk Plan van Eisen*). As with this Spatial Design Specification the Spaces Tree can also integrates the required amount of spaces and its dimensions. However, it is observed during the internship that the specification of the requirements in the Spaces Tree is heavily discussed within the Rijksgebouwendienst and Directie Advies & Architecten as it can decrease the level of freedom of the private consortium when highly detailed performance specification are integrated which minimizes the solution space. The reason that the Spaces Tree is perceived as the backbone of the OS document since all the requirements defined in the other Trees are linked in some way to the spaces and rooms defined in the Spaces Tree which is by itself related to the higher level Goals and Objectives. This position and relation of the Spaces Tree and the other OS elements is displayed in figure 11 by means of the UML modelling language.
UML (or Unified Modelling Language) is a standardized, general purpose modelling language which yields various graphic notation techniques to create visual models of object-oriented software-intensive systems. This modelling technique is used to indicate how the elements of the digital OS model of the Rijksgebouwendienst used in DBFMO projects relate to each other and how the Performance Requirements are used to define the quality level which is to be expected of the performance of the private consortium. The figure indicates the central position of the Spaces Tree in an OS model as all of the elements can be traced back to this element which integrates the definition of the rooms, which can be viewed as a categorization of relevant sub-rooms. For example, a specific sub-room can be related to 0 or more attributes of the group Comfort performance specifications, relates to 1 or more sub-objectives which are used to define the goals and sub-goals of the DBFMO project. In retrospect this means that the object of the DBFMO project and its performance based briefing is centralized on the required rooms defined by the project organisation based on input if the clients, end-users and customers. It is observed that this approach and structure is used in all of the DBFMO projects but at the same time its effectiveness if being discussed by multiple groups within the Rijksgebouwendienst. This discussion focusses on the possible centralization of the defined Activities and Business Process in the OS model and thereby to change the function of the Spaces Tree.

3.5 Conclusions

The Rijksgebouwendienst is commissioned with the management of the housing for the Dutch government. For the proper performance of their projects multiple tasks are transposed to one of the four directorates. Central in the performance and realization of DBFMO project is the Directie Projecten. This directorate is responsible for the performance of the projects after these are – currently – initiated by the Directorate Real Estate. When the potential of a project is acknowledge by this latter, a process proposition is formulated and the responsibility is transferred to the Directie Projecten. Central in the definition phase which leads up to the formulation of the OS document, is the performance of the requirements management process. This chapter only shortly indicated this process as only limited attention is provided on this subject by the documentation and knowledge-base of the Rijksgebouwendienst. An important element for this phase is the Nordic-Five level Structure which is regarded as the applicable framework by delegates of the Rijksgebouwendienst and standard for the formulation of performance requirements of the OS document. The latter is perceived to be highly centralized – its digital structure and thereby the functional decomposition for DBFMO projects – around the formulations of rooms.

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46 For this analysis an exemplary digital OS model is used of one of the most recent DBFMO project managed by the Rijksgebouwendienst, the Hoge Raad.
Figure 11 - Objects and relations in OS model presented by means of the UML modelling language
To perform a case study a pre-defined theoretical framework is required which is used as a perspective to assess the empirical data. This chapter provides this theoretical ground for answering Research Question 1:

**Research Question 2** = Which theoretical framework can be used which indicate the predicted performance of the process and indicate the normative elements of SE to enable the assessment of the current requirements management performed in DBFMO projects by the Rijksgebouwendienst?

By identifying the relevant elements in theories on requirements management and Systems Engineering the theoretical framework aims to serve as a bridge between the theoretical and empirical elements. This research project provides an assessment on the performance of the current requirements management process performed in DBFMO projects based on the academic fields of requirements management and Systems Engineering. One can question, how do those two relate to each other and how is this framework used to assess the empirical data derived from the case study? Paragraph 4.1 aims to provide answers on these questions by discussing the design of the theoretical framework. Paragraph 4.2 presents the input of the academic field on requirements management process. Paragraph 4.3 discusses the elements perceived as relevant for the normative SE model. Finally, paragraph 4.4 integrates this knowledge derived from the two academic fields and presents a summary of this theoretical framework.

### 4.1 Substance and use of framework

This theoretical framework is developed with two purposes as (1) it provides a perspective to assess the current performance of the requirements management process of DBFMO projects; and it is used to (2) identify the elements of the SE framework which are perceived as relevant to be implemented in this process. The first step relates to the formulation of a conceptual model which integrates the variables and relations that are perceived relevant for the performance of the requirements management process. These are identified by using the selected academic knowledge-base which is perceived relevant for the assessment of the process. This conceptual model indicates the predicted pattern represented by means of propositions which are used for the assessment of the empirical data.
The theoretical framework is used in the assessment of the empirical data on the practical performance of the process as indicated by figure 12. By means of reflection of the predicted pattern from the theoretical framework with the observed pattern from the empirical data the performance of this process can be assessed. This assessment investigates how the variables and propositions can be applied to the practical context and by means of the formulation of propositions these theoretical variables are connected to the empirical data to create insight in the process performed and in its strengths and weaknesses. At the same time this enables the discussion and enrichment of the academic knowledge-base since the knowledge on this subject in the context of PPP or DBFMO projects is limited.

The theoretical framework is expanded by integration of the Systems Engineering framework. Where the first academic field primarily discusses variables related to the performance of the requirements management process the latter integrates elements which are expected to have an added value for the improvement and development of the performance of the requirements management and performance-based briefing process for DBFMO projects of the Rijksgebouwendienst. The theoretical framework integrates SE elements which are perceived to be relevant for the formulation of the normative model in relation to the object of study. This is required since the SE framework is a methodology which ought to be applied to the full life-cycle of an project but for this research project only the definition phase is relevant. These elements are discussed on a highly theoretical level and by means of the empirical data this will be reflected on the current context.

This research project does not aim to develop a fully applicable SE framework for the definition process of the Rijksgebouwendienst since it acknowledges the importance to understand the contextual difference. When

47 The development of an applicable framework for the formulation of the output-specification document and the integrated performance specification is perceived to be the subject of an subsequent research effort but this is not the goal of this research. We acknowledge the
analysing the empirical data by means of the normative SE elements this research aims to indicate how the SE elements can be used to formulate a first SE application for the definition of DBFMO projects. The question remains, how is knowledge from the academic field on requirements management and SE related in the theoretical framework? The assessment of the current process on the six variables\(^{48}\) provides insight in the strengths and weaknesses of the current performance of the process. When discussing the relevance of the SE it is assessed how its application can improve these weaknesses and this knowledge is integrated in the normative model to indicate its pros and cons.

4.2 Requirements management process

This paragraphs aims to increase the reader’s perspective on this first academic field on Requirements Management. By means of an in-depth literature study on the state-of-the-art studies variables are identified which are perceived to have a significant influence on the performance of this process\(^{49}\). These variables are integrated in a causal diagram which enables the identification and visualization of the causal relationships to each other and the performance of the requirements management process. The definition of the relation between the variables and the performance of the process then are used to formulate the propositions which provide the connection between this theoretical framework and the empirical data.

4.2.1 Method for selecting relevant variables for conceptual model

At the start of the literature study it was expected that significant elements or characteristics could be identified which influences the ‘success’ of the performed requirements management process. Due to the absence of a quantitative analysis in this research or in the academic field\(^{50}\) the significance of the selected variables is not statistically justified. However, we tried to justify the selected variables by means of two approaches. Firstly, the variables are selected in accordance with the frequency level they are addressed in the studied literature. The main literature body that is used is presented in table 3 to give the reader some insight in the studies that are used and how they perceive the object of study. Secondly, by means of the unstructured interviews performed at the definition stage and the first set of semi-structured interviews\(^{51}\) the constructs are discussed and evaluated on their significance for the DBFMO projects.

Table 3- Requirements management in literature

\(^{48}\) Identified for the stakeholder- and methodology-perspective on the academic field of requirements management.

\(^{49}\) In the theoretical framework the ‘qualitative’ performance of the requirements management is perceived as the dependent variable. This concept used as the dependent variable which is influenced by the ‘independent variables’ which are the variables identified in the literature study to have an relevant influence on the performance of this process.

\(^{50}\) Due to the time constraint given to the research project we are not in the position to perform an qualitative analysis for the formulation of an conceptual model. It is envisioned that by means of an quantitative analysis – as factor analysis – an conceptual model can be established for the performance of the requirements management process. However, this is not the goal of this project but can be used as the basis for a new research project. For now, a literature study is the perceived as the only possibility for the formulation of conceptual model.

\(^{51}\) Performed in the context of the case study.
4.2.2 Variables for requirements management process

The basis of the conceptual model is found in the variables which are used to assess the performance of the requirements management process. Variables are perceived as the operationalization of abstractive constructs but for this research no constructs are identified in order to prevent any subject categorization by the author. For this theoretical framework six variables are identified which are perceived to be relevant in the relation to the process. The six variables which are identified using the academic knowledge-base on the requirements management process are:

- Experience of team with process
- Commitment and Resistance of stakeholders
- Roles of stakeholders
- Consideration of multiple perspectives
- Methods used for collection of information
- Knowledge on formal procedures of process
4. Theoretical framework

It is observed that the identified variables acknowledge the importance of the stakeholders and the interaction between these stakeholders since they are “at the core of the construction process and improvements in the process can be related to the stakeholder management” (Kamara, Anumba, & Evbuomwan, 2000). This is recently extended by Tang et al. (2013) who stated that “achieving efficiency and effectiveness of relationships among stakeholders during the briefing process is considered by many academics to be crucial in performance of PPPs.” These variables are perceived to be straightforward, but for the interested readers an further discussion on their substance and argumentation for selection of these variables is presented in Appendix E.

4.2.3 Conceptual model and propositions on variables

To create insight in how the theoretical context defines the relation of these variables with the performance of the process a causal diagram is designed. This causal diagram helps to understand how the variables of interest relate to the “quality” of the performance of requirements management process and which concepts are relevant. The causal diagram is presented in figure 13.

An example of such a relation between variables in the causal diagram is:

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52 These relations are mainly based on the work of (Kamara, Anumba, & Evbuomwan, 2000; Tang L., Shen, Skitmore, & Cheng, 2013; Ahmad, Adnan, Bari, & Adb Rashid, 2011; Yu, Chan, Chan, Lam, & Tang, 2010; Kamara, Anumba, & Evbuomwan, 2001; Miron, Leite, & Formoso, 2005; Ryd, 2004; Barrett, Stanley, & Sexton, 1999) (Shen, Li, Chung, & Hui, 2004; Yu A., 2006; Yu, Shen, Kelly, & Hunter, 2007; Kelly, Hunter, Shen, & Yu, 2005; Barrett, Hudson, & Stanley, 1999)

53 In this causal diagram the relations between variables are expressed by means of positive (+) and negative (-) relations. This means that if variable A and B are positively related an increase in A will result in an increase in B. The other way around this means that a negative relation between A and B will result in an decrease in B if an increase in B is expected. This use of the causal relationship is simplified as this is required by this research project. The positive and negative relations can be explained in a more complex manner but this is not required at this point and does not provide any added value for the used variables and there relations.
An increase in the **Incorporation of relevant stakeholder in the process** will lead to an increase of the **Perception on interests of relevant stakeholders for the project** which will result in a decrease of the **Resistance towards the project**.

This is one example of a relation which is identified during the study of the literature on the requirements management process. By means of this causal diagram and the knowledge of the literature study the propositions for each of these variables are formulated. These are presented in table 4. Where these propositions are based on the causal relations presented in the causal diagram, they are formulated by using a simplified pronunciation. This is done because these propositions provide a perspective in the research which is used to assess the process performed by the Rijksgebouwendienst in DBFMO projects.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Proposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience of team with process</td>
<td>Experience of the project organisation with performance of output-specification process in DBFMO projects will improve the performance of the process.</td>
</tr>
<tr>
<td>Commitment &amp; Resistance towards process</td>
<td>Stakeholders who are strongly committed to the process and project will improve the performance of the process by their participation in the process.</td>
</tr>
<tr>
<td>Roles of stakeholders</td>
<td>Clear definition of roles and responsibilities of delegates in project organisation will benefit the success of the requirements management process.</td>
</tr>
<tr>
<td>Consideration of multiple perspectives</td>
<td>Incorporating multiple perspectives – from stakeholders and within stakeholders – improves the input for the formulation of the requirements by increase of understanding of requirements.</td>
</tr>
<tr>
<td>Methods used for collection of information</td>
<td>Usage of a variety of requirements “trawling” techniques will create a comprehensive perspective on the stakeholders requirements due to the enrichment of information input.</td>
</tr>
<tr>
<td>Knowledge on formal procedures of process</td>
<td>Knowledge on the formal procedure required for the performance of the process will benefit the performance of the requirement management process.</td>
</tr>
</tbody>
</table>

Where these propositions expect a certain level of measurability of performance of the process it is acknowledged that the “quality” and “success” of the performed process are difficult to measure objectively. As a result, the propositions are used to examine their relevance and application in the process of the different cases based on the perspective of the professionals and experts that are interviewed; and to create insight whether or not this conceptual model is applicable in the context of a DBFMO project. For the variable **Consideration of multiple perspectives**, for example, it is indicated in the literature that this significantly influences the performance of the process and by evaluating how this is managed and integrated in the practical context insight is created on the process but also on the relevance of the variable.

### 4.2.4 Identification of knowledge gaps in literature on requirements management

In the causal diagram variables are integrated which at this point cannot be defined or which causal relation on the performance of the process cannot be indicated. The variable **Preliminary document and project statement** is already introduced but using the literature no direct causal relation can be defined. Despite this shortcoming this variable is integrated in the theoretical framework since it is expected to be of relevance for the process of the Rijksgebouwendienst and more insight in this variable can be provided by this research.
Another variable which is defined in the literature but which relation is unclear is related to influence of organizational factors. This is discussed in the literature but no clear causal relation is identified on the performance of the requirements management process. Ryd (2004) identified this variable as significant on their influence of the requirements management process but no clear definition was provided of how this related to the process. It referred to the organisational proximity of delegates. In another study it was expected that the appointment of a single client representative with a sufficient level of mandate can have a significant influence on the process but this was only discussed to an limited extend in the literature. The research project aims to create more insight in these two variables and their relation to the performance of the requirements management process.

4.3 Systems Engineering framework

The Rijksgebouwendienst aims to fully integrate SE as a tool in the definition, procurement and management of their projects. From an academic perspective it is found that the SE framework provides a positive contribution in the performance of project management of complex and technical projects. This research aims to create insight if the integration of the SE framework can benefit the Rijksgebouwendienst the performance of the requirements management process and thereby the definition of the output-specification for DBFMO projects. This insight is provided by coupling of the evaluation of the requirements management process – which identifies the critical elements, strengths and weaknesses of the process – with the relevant elements of the SE framework. This section presents a theoretical discussion on the SE framework and identifies the relevant elements which can be related to the object of study. This enables the formulation of an initial normative SE model which “makes claims about how things should or are to be performed” from a SE perspective. Before zooming in on the substance of the SE framework this paragraph firstly provides insight in why the integration of SE in construction projects is justified but why its application is lacking behind other sectors as infrastructure and aerospace.

4.3.1 Systems Engineering in construction sector

Justification for use of SE in project management paradigm of construction sector

The main justification of integrating SE in the project management paradigm is perceived to be its significant influence on the project delivery and project success. Different studies indicates that a significant percentage of complex technical projects in dynamic environments fail to deliver the project on time, in budget and with the required quality. Causes of these failures are identified to be the (1) uncertainty in the way projects must be governed, (2) high level of scope ambiguity, (3) technical complexity of projects, and (4) involvement of a large number of stakeholders. These failures are present in the construction industry but were also relevant in software, defence and aerospace sectors. This poor project performance is mainly the result of poor project planning, poor project initiation and the lack of the ability to comprehensively elicit and managed client

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55 Observed during the internship and indicated by the respondents in the interviews.
56 Related to the performance of the output-specification or requirements management process.
57 Different percentages – dependent on their perspective and moment of study – are indicated both in the work of (Locatelli, Mancini, & Romano, 2013) and (Emes, Smith, & Marjanovic-Halburg, 2012).
58 Derived from (Locatelli, Mancini, & Romano, 2013) who bases it work on Van Marrewijk et al. (2008).
requirements and user satisfaction. In order to perform these projects properly the traditional project management approach is no longer sufficient. These projects demand the project organisation to satisfy the time and budget constraint but also satisfy the (dynamic) stakeholders’ requirements and cope with the technical complexity. The dynamic and complex environment of these projects requires a shift or change in the project management paradigm, from a project management perspective to a “system governance” or system perspective as is framed by Locatelli et al. (2013). The first refers to the “hard system thinking” concept which copes with well-defined projects, reliable data, clear objectives and systems that can be optimized by classical engineering methods (Checkland P., 1999). The latter refers to the “soft systems thinking” concept which is able to cope with problems involving incomplete data, unclear goals, dynamic environments and human being & cultural considerations. As the hard systems thinking is not able to cope with the technical complexity, high level of uncertainty and dynamics of project environment, the project management paradigm needs a transformation to soft systems thinking to safeguard the qualitative performance of the project. The positive contribution is identified by Locatelli et al. (2013) and Janice & Mengel (2008) as “most of the successful project in complex environments have applied certain principles and practices which can be traced back to SE.”

Scholars perceive the SE methodology as necessary to provide this transformation which is relevant for the construction sector but in which this is still lacking (Locatelli, Mancini, & Romano, 2013). This adaptation of SE is applied in the defence, aerospace, infrastructure and software sector and there it has proven its added value to the level of project success. For example, in the defence sector of the UK SE has been adopted for over the last 10 years as a main element for planning and delivery of complex project. As a result there has been a significant improvement in the project delivery in terms of budget, time and quality. In the aerospace sector, the Boeing Commercial Airline Group states that the success of the Boeing 777 is substantially influenced by the adaptation of SE in its design and realisation (Gartz, 1997).

Lacking adaptation of SE in construction industry

As construction projects are becoming more ambitious and complex they require an alteration of the current project management paradigm as is indicated in the previous section. Although the value of SE for construction is starting to be recognized, this industry has been very slow to adopt the principles of SE (Emes, Smith, & Marjanovic-Halburg, 2012). The integration of SE in project performance in the construction sector is perceived to be limited as “the practice of Requirements Management and SE in aerospace has no direct equivalent in construction” (Fernie, Green, & Weller, 2003). In the Dutch construction sector the use of SE is relatively unknown and only recently the discussion on its level of suitability is initiated (Stichting Pioneering, 2013). This

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59 Conclusion based on work of (Locatelli, Mancini, & Romano, 2013) and (Fernie, Green, & Weller, 2003)
60 Referred to as Project Governance in the work of (Locatelli, Mancini, & Romano, 2013)
61 As is framed, this qualitative performance can not only be expressed in traditional project management performance indicators as Money, Time, Quality but the projects complexity – technical, organisational and societal – demands a more integrated and soft project performance.
62 Of for example the USA and the UK. (Emes, Smith, & Marjanovic-Halburg, 2012; Locatelli, Mancini, & Romano, 2013)
63 Measurement in user satisfaction, based on the work of (Emes, Smith, & Marjanovic-Halburg, 2012)
64 At this point the construction sector is perceives to integrate the realization of housing, office buildings as commercial construction.
lack of adaptation of SE by the construction sector can be explained by two main arguments\textsuperscript{65} as the sector is perceived to be unwilling or incapable to develop and integrate the SE methodology in its practice\textsuperscript{66}.

The unwillingness of the sector relates to the traditional procurement method which determines the current performance of projects and the implementation of SE is frequently perceived as a threat instead of an opportunity. Designers and managers of – for example – an public organisation as the Rijksgebouwendienst are perceived to work according traditional methods in which they are used to prescribe the solution in the procurement of an project. However, due to the decrease of the active role of the government and increase of the use of integrated contracts (UAV-GC) and PPP contracts (as DBFMO) a different approach and mindset is required. The use of the SE is perceived as to be able to deal with this transition but practitioners are unwilling to change their traditional approach as the fear the decrease of control on the end-result. In addition, the organisations that perform these projects – both public and private – are perceived to be unwilling to integrate the SE practice in the performance of their projects since its development and integration requires an investment of time and resources. It is widely considered that insufficient resources are allocated to requirements elicitation and use of SE tools in construction. Therefore it is perceived to be problematic to overcome the limitations of the highly traditional approach of practitioners when the organisations are not willing to invest in the development and integration of SE in the practice (Fernie, Green, & Weller, 2003; Stichting Pioneering, 2013).

On the other side, the sector is perceived to be incapable to integrate the SE methodology in its practice. Ground for this statement is that construction professionals are alleged to rush in to the formulations of solutions for the problem before understanding the nature of the problem (Fernie, Green, & Weller, 2003). This is the result of the traditional approach in which it is not required to have clear perception of the solution due to its iterative and reoccurring nature. The use of SE requires the designers and project managers to firstly define the problem more extensively and formulate the requirements of the system at the outset of the process. This requires a different mindset and approach in the definition, procurement and realization of construction project from both the private and public stakeholders. It is questioned – in the used literature – whether or not the practitioners and organisations in the construction sector are capable to change their practice and traditional mindset in order to adopt the SE methodology. Even if some of the SE tools and elements are recognized in the current project management performance of the construction sector, the SE approach to them is radically different (Locatelli, Mancini, & Romano, 2013). The key conceptual difference between SE and traditional PM tools is the result of different focus, namely a system-perspective versus project perspective. The holistic approach of SE requires a change in the point of view and the use of its analyses. For example, the principals of integrated works contracts are perceived to be incapable to use the concept of functional specification which is a fundamental concept of the SE methodology since the added value towards the definition of the system – the project – is not fully recognized. On the other side, the agents – the

\textsuperscript{65} These two arguments closely relate to each other, or can be viewed as one argument. In order to increase the readers perception, both of these arguments are discussed.

\textsuperscript{66} Based on the work of (Fernie, Green, & Weller, 2003; Stichting Pioneering, 2013)
contractors – perceive the use of SE as an controlling methodology for the principal and don’t acknowledge the added value it can have on their own business process which is the delivery of the defined system (Fernie, Green, & Weller, 2003; Stichting Pioneering, 2013).

A more technical factor which limits the level of adaptation of the methodology in the construction sector is the incomplete knowledge in this sector on the concept of SE and its elements. Different sources indicate that organisations – practitioners, knowledge bodies or research institutes – have only limited knowledge on the SE methodology and how this can be related to the construction process. As a result the development and/or use can be wrongfully, inadequate or incomplete. This wrongful application is increased when construction researchers continue to search for instrumental improvement techniques from other sectors in isolation from a grounded understanding of equivalent practices in construction (Fernie, Green, & Weller, 2003). The context of the construction sector – the product, the environmental factors and social complexity and impact of the system – could not be more difficult than the aerospace sector and therefore the development of the SE methodology for this sector should not only be based on lessons learned from other sectors but should incorporate lessons learned from the construction sector. For example, one can question how the functional decomposition can be applied to an office building which functionality is determined by its total performance and impact on social perception.

### 4.3.2 Theoretical foundation of Systems Engineering

After the Second World War, SE is developed as a discipline for governing the development of military and aerospace projects. The number of works on SE provides an equal amount of definitions and discussions on its substance which means it is rather difficult to provide a single definition on SE. The most common and accepted definition is of INCOSE (2010):

> “SE is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and systems validation while considering the whole problem. SE considers both the business and the technical needs of all customers with the goal of providing a quality product that met user needs.”

Based on this definition SE is viewed as a multidisciplinary approach which manages the technical and managerial aspects of a project (Locatelli, Mancini, & Romano, 2013). The technical aspect manages the “system” which is characterized by substantial technical and social components. The management aspects relates to the governance of the technical work – development, design and deployment – and this is seen in the inclusion in SE of processes to manage the project. Integrating these elements it is perceived that SE merges traditional, technical and managerial disciplines into a holistic systems approach.

This abstractive definition presents an initial outline of the key elements of the SE framework. The concepts of systems perspective, life-cycle approach and stakeholder integration are identified as key concepts of the SE
framework but this does not provide a full understanding of its workings. To increase the reader’s perception on this framework a discussion on the theoretical foundation of the SE framework is presented based on the work of Sage & Armstrong (2000). In their work they suggest that SE is a “management technology to assist and support policy making, planning, decision-making and associate resource allocation or action deployment by performance of quantitative and qualitative formulation, analysis, and interpretation of the impacts of action alternatives upon the needs perspectives, institutional perspectives, and the value perspectives of their clients or customers.” The three key concepts of the SE framework are used to present a more abstractive discussion on the working of this “management technology”.

**Systems thinking as central pillar in SE**

Firstly, SE takes a “big picture” or holistic view of large-scale and complex problems and their related technical solutions. Systems are defined as “a group of components that work together for a specified purpose.” These components not only relate to the object but also to its surrounding environment. Due to the highly complex nature of systems, and the fact that they are comprised of many subsystems the concept of system of systems is used. Systems are better understood by creating an overview of the subsystems or by organizing their parts into groups based function or other principle. This use of systems thinking combined with engineering principles focused on creating added value for stakeholders is perceived to be a central pillar of SE.

**Life cycle approach for management of SE projects**

The second fundamental concept of SE is related to the systems life cycles. A system life cycle is perceived as a conceptual model used to describe how a system develops over time. From the academic literature the life cycles definition of the requirements for a system, development of the system itself, and deployment of the system in an operating environment are identified as presented in figure 14. These relate to the basic activities of system engineer but each of these phases can be associated with the steps of formulation, analysis, and interpretation.

An important element which is characterized in figure 14 is the iterative nature of an SE process. The iteration in the process represents the constant verification and validation of steps with the requirements and constraints defined in preceding steps to ensure the appropriate development of the system. An SE process should support bottom-up and top-down approach to ensure that the system meets the needs and expectation.

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68 Derived from the work of Sage & Armstrong (2000)
of the stakeholders; and the constraints and requirements placed on the system by institutions and other environmental factors (Locatelli, Mancini, & Romano, 2013; Sage & Armstrong, 2000).

**Stakeholder integration central in management of SE projects**

The last key concept relates to the importance of stakeholder integration in an SE process as “the primary focus of any Systems Engineering effort is on the stakeholders of the system.” (Parnell, Driscoll, & Henderson, 2008). This is perceived as fundamental because stakeholders will care about the system because it affects them in their being. SE acknowledged their importance and structurally integrates their needs, wants, desires and requirements in the systems requirements which determine the solution space. It is observed in the different studies on SE that the initial phases of the process must consists of activities in which the stakeholders are identified and where their requirements are integrated as a basis for the final system development. In addition it is observed that SE has a highly explicit character when it comes to documentation of – for example – requirements and decisions. Many tools are used which have the goal to gain insight on the objectives and wishes of these stakeholders. By means of visualization techniques the output is documented. At the same time this documentation increases the communication of this output between the stakeholders and decreases the loss of information over the project life cycle.

**4.3.3 Systems Engineering for requirements management process**

As the previous section introduced the core concepts of SE, the goal of this research study is to evaluate the relevance of the application of SE in the requirements management and definition of DBFMO project by the Rijksgebouwendienst. To reach this goal the SE framework – which encompasses a broad range of elements, tools, techniques and methodologies – is delineated in this section according to the substance of the object of study. This provides the theoretical foundation used in the research. The empirical knowledge gathered by the case study enables the reflection of this theoretical foundation on the current practice of the Rijksgebouwendienst in order to assess the relevance of the application of SE.

As is already acknowledged in the previous section, an SE process should be performed to support system product evolution of time and enables management of all relevant factors of the systems life cycle. Multiple definitions are available which illustrate the SE life-cycle phases. These vary from the three primary life cycle phases of System Definition, System Development and System Deployment to the Twenty-Two Phase Life Cycle\(^69\). The latter provides a detailed – and doubtlessly exhaustive\(^70\) – discussion of the activities that are to be performed in the three phases of the primary SE life cycle. However, these models are all patterned after the U.S. Department of Defense (DoD) SE life cycle. The DoD Se life cycle is presented in figure 15 as this is perceived to be an suitable overview of the SE process.

\(^{69}\) For a more detailed discussion the reader is referred to Chapter Two of Sage & Armstrong (2000)

\(^{70}\) Stated by the author.
According to the work of DoD (2001) the SE process can be simplified by three main steps or phases and in this model these are referred to as the Requirements Analysis; Functional Analysis; and Synthesis. The process input and output are perceived as relevant elements in an SE life cycle and obtain an important position in an SE process and may not be neglected. The three steps in the DoD life cycle closely relate to the steps of System Definition, System Development and System Deployment which are observed as the basic phases of any SE process (Sage & Armstrong, 2000). The primary goal of these three steps is the creation of a set of high-quality and trustworthy operational product and services that will enable the accomplishment of desired tasks that fulfill identified needs of the relevant stakeholders.

The Requirements Analysis involves further defining stakeholder’s needs and objectives in order to track satisfaction of stakeholders in the project/system context characteristics to determine requirements for the system functions (Department of Defense, 2001). These requirements indicate the performance which is required from the system and its top-level functions to deliver. In order to determine the requirement for these system functions in this phase an system decomposition must be provided which defines the top-level functions of the system. These top-level functions are coupled with the formulated requirements and objectives by the stakeholders and project constraints. This safeguards the fact that the system is further decomposed based on contradictory or dissatisfactory requirements which do not meet the stakeholder expectations. This output of the Requirements Analysis serves as the input for the Functional Analysis in which the top-level objectives and functional decomposition is further decomposed in line with the project.

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71 For example, the process input relates to the stakeholders needs and wants and other environmental factors which influence the solution space and development of the system.
constraints and requirements. To represent this phase and the life cycle of the SE process the V-process model is used in figure 16 to indicate the relation of the phases and their position in the OS process. This process model – introduced by Ould (1991) – is frequently used to characterize the top-down and bottom-up approach of an SE process. It also presents the importance of the constant verification and validation of steps taken in the process.

When the system decomposition and system requirements are validated on the input of the stakeholders the SE process proceeds with the performance of the Functional Analysis. This step has the goal to further define the problem by means of the functional decomposition of the top-level decomposition provided by the preceding Requirements Analysis. Lower-level functions or subsystems need to be formulated which contribute to the fulfillment of the top-level functions, goals and objectives of the system. As with the top-level functions the initial requirements should be analyzed and coupled to these lower-level functions to which the design of the systems must be validated. By means of this verification the functional decomposition can be used in the subsequent phase to generate solutions for the system requirements. This verification yields the identification of the traceability of the input of the stakeholders as the decomposition needs to be a lower-level translation of the system requirements which are based on the initial input of the stakeholders. When these are wrongfully translated a functional decomposition is used in the design of solutions in the Synthesis phase which will not fulfill the stakeholder’s expectation towards the system.

Problem Definition and Requirements Analysis for practical process in DBFMO projects

For this theoretical framework this SE life cycle is related to the process in which the Rijksgebouwendienst comes to the formulation of the OS document by means of the requirements management process. Insight on this process provides grounds for the selection of the Requirements Analysis and Functional Analysis – enriched with the Input Analysis or Problem Analysis – to be related to the practical process of the Rijksgebouwendienst. This latter process entails the extensive collection and analysis of requirements – from multiple sources – for

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74 For this discussion a linear process is assumed but in practice the different phases of an SE process obtain a high iterative character.
the real estate object of the Rijksgebouwendienst and the translation of these requirements into functional specification and performance requirements to be integrated in the OS document. The latter step of the SE process – Design Synthesis – is perceived to be the responsibility of the private consortium which is selected for the tender of the DBFMO contract. The OS document is used as a communication and management tool by the Rijksgebouwendienst which integrates the objectives, requirements (on different levels) and performance specifications.

However, as these phases are closely related to the practical process of formulation of the OS document the delineation of this research focusses on the requirements management process which is performed in order to indicate the high-level objectives, goals, requirements and functionalities towards the system as the further definition of low-level performance specification is not the knowledge-field of the author. For this research project the first two stages of a SE process – Problem Definition and Requirements Analysis – are relevant and used in the assessment of the relevance for application in the object of study. These two stage of a SE process and some initial methods and techniques is discussed in Appendix F on a abstractive level to indicate their substance based on the discussion of Sage & Armstrong (2000). At this point it is not the goal to provide an detailed discussion on how these phases are to be performed as this is dependent on the project/process which is managed. Insight on how these SE phases – and relevant tools/techniques – can be integrated in the practical process of the Rijksgebouwendienst is provided in Chapter 6. By the providence of this description of the Se methodology in relation to the object of the study it is tried to indicate how this framework is used and which SE elements are taken in consideration for the assessment of its relevance in the integration in the current DBFMO practice of the Rijksgebouwendienst.

4.4 Conclusions

In this chapter the central elements of the theoretical framework are presented and discussed. In addition, in line with the discussion in Chapter Two – Research Method – the application and use of this framework in the research project is discussed to increase the readers perception. Using the input from the requirements management and Systems Engineering theoretical fields a theoretical framework is formed which provides an perspective to assess the emperical data is collected by means of the case study. By using this knowledge variables and propostions are formulated for the perspective derived from the requirements management framework which are to be reflected on the practical performance of the process as figure 17 indicates. This summarizes the preceding findings in one overview of the substance of the theoretical framework. Further, knowledge from the SE methodology is used to select the phases and initial elements which are perceived to be relevant for the assessment of the relevance for application of this framework in the current requirements management practice in DBFMO projects of the Rijksgebouwendienst. It is framed that the focus of the research – on the relevance of SE in requirements management in DBFMO – is on the Problem Definition and

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73 It is acknowledged at this point that the description of the SE application is still on a very theoretical level. By means of the knowledge on the emperical data the normative model presented in the remainder of this thesis will be on a more practical level.
Requirements Engineering elements of which the potential added value and relevance is discussed in Chapter Six based on the empirical findings and knowledge gained by the case study performed.
Part II

Empirical Findings
5. Requirements management in practice

This chapter presents the findings from the analysis of the requirements management process from the perspective derived from the theoretical framework. This theoretical framework identifies six variables which are expected to influence the quality of the process performance. By using this framework this chapter aims to (1) increase the perspective on the current empirical performance of the process in DBFMO projects by the Rijksgebouwendienst; and (2) to reflect the relevance of these variables on their application in the context of DBFMO projects since these are primarily based on the traditional procurement practice. Thereby, this chapter answers the third research question defined in this research project using the requirements management perspective:

**Research Question 3 =** How can the performance of the requirements management process in DBFMO projects – managed by the Rijksgebouwendienst – be evaluated in terms of this theoretical framework?

In order to appreciate the analysis in its correct context, it is important to keep in mind that the findings are based on the multiple-case study performed for this research project. Within the context of three DBFMO projects multiple interviews are conducted and archival data is analysed to gain insight in the current performance of this process. As the findings in paragraph 5.1 present a broad discussion of the empirical data on the variables, the analysis and discussion of these findings is presented in paragraph 5.2. This analysis and discussion presents the coupling of the empirical findings on the practical performance – the *observed* – to the causal relations defined by the theoretical framework – the *predicted*. This enables the assessment of the academic knowledge on its relevance and applicability on the practical performance of the process in the context of DBFMO projects. In retrospect, this also enables the identification of strengths and weaknesses of the current practical performance by using this reflection of the academic knowledge-base on the empirical findings. These are discussed by means of an SWOT analysis performed for the current practice of the Rijksgebouwendienst. This SWOT analysis is presented in paragraph 5.3.
5. Requirements management in practice

5.1 Empirical findings on requirements management process

5.1.1 Variable 1 – Experience of team with process

Limited level of experience of OS team with process for DBFMO

The performance of DBFMO projects is relatively new for the Rijksgebouwendienst since this mode of procurement is institutionalized in the Dutch government in 2004-2005. This new use of DBFMO projects and the performance-based briefing is expected to influence the initial level of experience of the project team which is responsible for the performance of this procurement, the requirements management process for performance-based briefing and the formulation of the OS document. Although the three exemplary projects are performed in a different time-span, it is observed that the coordinators of the OS team and other delegates in this team only had limited experience on the concept of requirements management process required in DBFMO projects. The team coordinators all did this for the first time. This could have been expected from the pilot project of the DUO/Belastingdienst but analysis of the other cases indicate a limited increase of the experience with the use of performance-based briefing and the formulation of the performance specification based on the information gathered in the process.

The reason for this relative little experience was perceived to be caused by the unattractiveness of this function for professionals of the Directie Advies & Architecten, as it is seen to be “not appealing from a career perspective”. The majority of the coordinators of the OS teams indicate that they only performed this function once before they were appointed a different, more interesting function in the Directie Advies & Architecten, or even another directorate. As with this limited attractiveness of this function, only a small amount of delegates active in the DBFMO project organisation – in OS team and other relevant teams – where active in the project phases performed after the OS document was completed. There are some exceptions, but a great deal of the team coordinators for example did not participated in the subsequent phases of the project even though in this process insight on the performance and quality of the OS document can be directly gathered.

“It is normal practice that members of the Directie Advies & Architecten will perform the role of AV’er only one time and then perform an different function within the directorate, or even another directorate. As a result, the knowledge derived from the management of the formulation of OS document is frequently lost. This knowledge is observed to be very important because it can be stated that the project and the requirements management process fail when the OS is not properly designed.” Respondent AA on the loss of knowledge on the process and the importance of proper knowledge management.

“We are the two responsible Rijksgebouwendienst delegate for the Output-Specification process and it was the first time we managed this process. We needed to do research on the approach that we should use in this process. Obtaining information on the used methodology within the Rijksgebouwendienst was difficult and we needed to use

The result is that the experience – and knowledge – derived from this process is transferred within the organisation and lost if not properly managed. It is indicated by multiple respondents that the knowledge management on these elements is not optimally performed and is not structurally safeguarded.
“Our experience as project leaders of traditional projects in the formulation of our approach.” Respondent D on his first time as coordinator of the OS team with Respondent E.

“Within the organisation of the Rijksgebouwendienst it lacks a structural documentation of processes and performed activities. As a result, the knowledge management and learning ability of the organisation is decreased. The professionals of the Rijksgebouwendienst operate on their one and don’t use a structural approach to document knowledge. Quality management therefore is lacking behind the required level by the Rijksgebouwendienst.” Respondent G on the limited level of structural knowledge and quality management in the Directie Projecten.

“As this was my first DBFMO project as coordinator of the OS team, I was obliged to ask around on the approach in the OS process and why certain steps are required. These questions could not always been answered as result of the inavailability of knowledge or the lack of a best-practice. Only after the performance of the process you know as team coordinator how this is optimally performed, which processes are required and which strategy should be used. At the start of the process I had no clear perspective on these elements since I lacked the experience and knowledge.” Respondent H on the effect of his lack of knowledge on the performance of the process.

Performance-based briefing influenced by experience from traditional procurement projects

It is learned that the limited knowledge and experience indirectly influences the approach used in the requirements management process. Due to this limited experience of the stakeholders in the OS team – which constitutes on the level of acceptation, knowledge on processes and perception on substance of performance-based briefing – performance of the process and formulation of the OS document is primarily based on experience derived from traditional procurement practices. The respondents indicate to have significant experience\textsuperscript{75} in the performance of traditional procurement projects and their mindset derived from these experiences significantly influences the performance of the process in context of a DBFMO project. In addition, the respondents indicate that the amount of education in the important concepts and elements of DBFMO projects is lacking perceived to be limited.\textsuperscript{76} In essence, the activities performed in the process in traditional procurement projects are not different for DBFMO or PPP projects but the abstraction level and substance of performance-based briefing require a different mindset\textsuperscript{77} from the professionals. As a result of this limited experience in the performance of the process in the context of performance-based briefing and PPP, in combination with the high level of experience in the field of traditional procurement projects, the exemplary cases indicated that the performance-based briefing concepts and the qualitative formulation of the OS document is not structurally safeguarded over the projects. This is presented in figure 17. As a result, the performance specifications and the general substance of the OS document can integrate a high level of solution-oriented prescription instead of the performance-specifications when the mindset required for DBFMO is not acquired in the OS team and is not safeguarded in the process. Analysis of OS documents of DBFMO projects and interviews with delegates responsible for these documents identified the influence of this

\textsuperscript{75} Some members of the Directie Advies & Architecten who are active in project organisations of DBFMO projects have more than 20 years of experience in performing traditional procurement projects.
\textsuperscript{76} A 2-day course on DBFMO was given by the Rijksgebouwendienst but the respondents indicate this to be insufficient in order to appreciate the substance and requirements for the performance of performance-based briefing. In addition, it is observed that the Rijksgebouwendienst – Directie Projecten – cancelled this course.
\textsuperscript{77} Indicated in the theoretical framework on the use of performance-based briefing in PPP projects.
limited experience with performance-based briefing on two different abstraction levels, namely on the used structure of the digital OS model and the high level of solution-orientation in the performance requirements.

As is introduced in Chapter Four, the current structure of the digital OS model is based on the use of a Spaces Tree as the backbone of the performance-based briefing. This structure is heavily discussed and criticized by delegates of the Rijksgebouwendienst. The delegates state that the digital OS model should enable a focus on the required system functionalities requirements derived from the high level objectives and goals of the stakeholders which is perceived to be the objective of performance-based briefing. However, the respondents indicate that this isn’t achieved at this moment since no knowledge is available how this should be applied in DBFMO projects and therefore they observe a very traditional approach in the use of the OS model.

On the high level of solution-orientation of the performance requirements it is observed that some coordinators of the OS teams indicate that the added value of the formulation of the objectives and goals were unclear for them and they immediately started with the formulation of the required spaces, the spatial relations and required facilities which are to be provided for by the consortium. The other elements of the OS document – Comfort; Facilities; Safety; Spatial Relations; Services – can be defined in such a way that the Rijksgebouwendienst takes up the tasks of the system design which is perceived to be the central tasks of the private party in a DBFMO cooperation. It can also prescribe the required subsystems and components required without realizing the influence of the design of the consortia on these elements. An example is found in a project in which the OS document prescribed a number of cameras to be installed by the consortium in the product. This is perceived as a solution-oriented requirement since it specifies design elements as the system design of the consortium directly influences the requirements for the use of cameras if necessary.

Due to the transition and implementation of DBFMO projects the concept of specification is changed. The persons who are responsible for this process have been trained in this but it is observed that the practical application is not always done effectively. In addition, if there is no team coordinator who manages the specification process of the experts properly then it is observed that the specification yield an high level of solution-oriented derived from
5. Requirements management in practice

practice of traditional procurement projects.” Respondent AA on the influence of the traditional procurement experience on the approach in DBFMO projects.

“In the formulation of the OS document the delegates of the Rijksgebouwendienst have the tendency to think very constraint by their knowledge of traditional procurement projects. The specification in the OS integrate the precise specifications of rooms and distance required between those rooms instead of formulating what is required from these rooms.” Respondent F on the high level of solution-oriented specification instead of performance requirements specification in OS document.

“I choose to be the only one who could work in the OS model and formulate the specifications. Experience showed me that consistency would not be safeguarded when multiple experts would work in the document. In addition, I learned that the technical experts of the Rgd and Rijksbouwmeester still work in an traditional manner and think in solution-oriented specification instead of adopting the PPP concept.” Respondent B on the minimization of the role of the expert due to their traditional mindset.

“In theory, one should start with an extensive definition of the problem and the objectives & goals of the relevant stakeholders. However, it is observed that in practice the team just starts with the formulation of the OS and the Spaces Tree because this is obligatory. From their traditional perspective they don’t understand the added value of these abstract elements in relation to the performance-based briefing concept of the OS document.” Respondent A on the influence of a traditional mindset on the approach used for formulation of the OS.

“I remember that one end-user was writing an vision on the business process to be performed in the new real estate. However, this took very long and we perceived the Spaces Tree as the important element of the OS so we started there and worked our way up.” Respondent D on the important position of the Spaces Tree in an digital OS document.

“In my function I am active in the field of spaces and functionalities. In traditional construction projects I am mainly active in formulating spacial and functional Design Specifications and this closely relates to these activities in formulating the requirements in the OS process.” Respondent J on its perspective on the relation between the mindset of traditional and DBFMO procurement projects.

“Delegates of the Rijksgebouwendienst not always understand the influence the use of DBFMO has on their activities and what is expected from them by this mode of procurement. They tend to grasp on the traditional approach and process and don’t are as flexible as is required from this relative new mode of procurement. The result is that within the projects of the Rijksgebouwendienst an different specification of performance requirements and OS documents is formulated.” Respondent G on the effect of the traditional mindset within the Rijksgebouwendienst on the performance of DBFMO projects.

5.1.2 Variable 2 – Commitment and Resistance of stakeholders

Different sources of resistance in definition of DBFMO projects

Commitment of relevant stakeholders to a project or process is key for the success of a project whether this is a traditional procurement project or a PPP procured projects. Reconfiguration of the housing of an organisation – by means of renovation or new construction – will always invoke a certain level of resistance towards the project. It can be questioned whether this resistance is different in traditional procurement project, but it is
important for the Rijksgebouwendienst to realize where this resistance is founded; and how this influences the performance of the process. Knowledge on the sources and influences of this resistance can be used by the Rijksgebouwendienst for the management of this process and the creation of commitment to the process and thereby project.\(^{78}\) The different sources of resistance and their relation to the variable are presented in figure 18.

![Figure 18 - Different sources for level of resistance of stakeholders](image)

Firstly, it is observed that the decision to use DBFMO as a mode of procurement for the project will increase the level of resistance among the important stakeholders towards the project. The hierarchical decision\(^ {79}\) to use PPP and DBFMO in the realization of the project is observed to be the primary source of resistance for a great deal of the end-user organisation and some project owners. Some of the respondents question the objective nature and substance of this financial analysis model which provides the argument for the selection of the mode of procurement. Secondly, it must be noted that this hierarchical decision on itself not only invokes the resistance towards the process. The end-users are perceived to have only a limited knowledge on the concept of PPP and DBFMO and fear that this use of mode of procurement decreases their level of control.

In the Hoge Raad project it is observed that the delegates of the Hoge Raad had the impression that they had little control on process, and thereby the end-result of the project. They felt that their primary objectives and interests were not incorporated in the requirements management process. This is also observed in the Defensiemuseum project in which the hierarchical decision resulted in a forced cooperation for two museums. The delegates of the museums expressed their initial fear that they would only have a very limited role in the process, or that they were “left out of the process” and would have no control or influence on the process.

As the respondents indicate that they felt that they had limited control on the process and could minimally influence the process, it is observed that this resistance also comes from the fact that they could not fully relate

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\(^{78}\) As the variable refers to commitment and resistance among the relevant stakeholders it is primarily the resistance which is been discussed in this paragraph as these two are closely related and management of resistance is perceived to result in the creation of commitment.

\(^{79}\) This relates to the fact that policy states that real estate projects with an investment value which is more than € 25 million must be analysed by using an PPC analyse if the use of a DBFMO agreement can result in "Value for Money".
to the process. In the projects, the user satisfaction of requirements management process is influenced by the level they recognize their input in the process and that they feel that they have significant influence on the substance of the process. A significant problem in the requirements management processes is the low level of requirements traceability and structural documentation of information-input during the process. When stakeholders didn’t recognize their input (in periodic documents, requirements databases or notes) this can increase the level of dissatisfaction with the process and thereby their resistance to cooperate in the process. In the current practice in DBFMO projects there is only limited attention provided to the structural documentation of the input of the stakeholders and this is dependent on the professionals of the Rijksgebouwendienst. A risk of this approach is that the input of end-users is not properly documented and translated in order to be used for the formulation of the substance of the OS which can ultimately result in a decrease of the commitment of these stakeholders to the process.

"It is important to realize that it was difficult for the end-user to accept the method of DBFMO as the right one for this project. The end-user had doubts on the use of PPP because they thought there would be little control on the end-result of the project." Respondent O on the limited acceptance of delegates of the Hoge Raad with the use of DBFMO as mode of procurement.

“A great deal of resistance was a result of the fear that the large amount of knowledge (of the museum organisation) on the exploitation of a museum would not be used since someone with relative limited knowledge shall act on our behalf.” Respondent V on the resistance within the end-users of the Defensiemuseum project.

“The performance of this initial process was troubled by the fact the end-user found it difficult to accept the use of DBFMO as a mode of procurement for this project. They thought that this use would decrease their ability to control the process and the architectural quality of the end-result. They questioned the theoretical substance of this PPP project.” Respondent O on the source of resistance in the Hoge Raad project.

“The output of the user groups was initially aimed to be used as input for the formulation of the objectives and goals integrated in the OS and ambition document for the project. However, as a result of the limited documentation and translation of the output of these sessions this was not formalized in the process and used in the formulation of these documents.” Respondent R on the limited structural integration of end-user input in the requirements management process.

Effect of resistance of stakeholders on requirements management project

As a result of this level of resistance the performance of the requirements management of the three exemplary DBFMO projects is negatively influenced. In one project, the Defensiemuseum, it is observed that one end-user organisation not fully participated in the process as they lacked to provide the information requested by the project organisation and OS team. As the goal of the process is to identify, document and translate the user requirements in performance specification for the OS document, the project organisation is dependent on the input from these stakeholders. Since these actors not fully participated in or acknowledged the “sense of urgency” for the process it is observed in the archival data for this project that the formulation of the OS

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80 The private consortium in the exploitation of the project.
5. Requirements management in practice

document was delayed by a significant period not to question the quality of the information input by these stakeholders. Aside from this delay by the limited participation of the stakeholders, the resistance and low level of acceptance of the projects can influence the definition and scope of the project as result of the fear that stakeholders will not have the desired level of control on the end product. This is observed in both the DUO/Belastingdienst and Hoge Raad project where the resistance influenced the initial definition of the scope used for the project. This can not only influence the requirements management project but also the efficiency and quality of the total performance of the DBFMO project.

5.1.3 Variable 3 – Roles of stakeholders

Differentiation in stakeholder management in DBFMO projects

The exemplary DBFMO projects provide a varied set of stakeholders which participated in the DBFMO project and the requirements management process. The fact that the projects were performed in a different time span enables the research to analyse the stakeholder management performed in the projects and how this developed as experience is gained. However, a consequent or standard stakeholder management approach cannot be identified in these projects and a diffuse set of roles and responsibilities for the different stakeholders in the process are observed. Different factors on stakeholder management are identified which influence the performance of the process, namely the (1) level of structural and considered definition of roles and responsibilities of stakeholders; (2) level of acceptance of role and defined boundaries of responsibilities (if known); (3) level of consequent performance of role by professionals of Rijksgebouwendienst; and (4) level of mandate of delegates of stakeholders in process.

It was expected that – as a result of the experience of the organisation of the Rijksgebouwendienst with the performance of construction projects – a structural method was used to position the stakeholders in such a way that which provides an “optimal” process. However, the three exemplary projects show a high diversity of roles, powers and responsibilities obtained by the different stakeholders\(^\text{81}\) in the process. This high differentiation does not have to be perceived as negative, when this is used to enable the achievement of a certain goal, cooperation and process performance this is only a means to an end. However, this differentiation is not perceived to be the result of a structural consideration of formulation of responsibilities to optimize the process. An underlying factor – which influences this configuration of roles – is that delegates of the Rijksgebouwendienst find it difficult to balance between satisfying their clients and taking their responsibility for management of the process. In the Hoge Raad projects the coordination of the process – and the coordination of the OS team – was performed by an delegate of the project owners; in the Defensiemuseum project the project owner established an very strict organisation which resulted in a limited role for the end-users and their “empowerment” in the process; and in the DUO/Belastingdienst project the delegates of the Rijksgebouwendienst were perceived by the end-users to take up an very central role in the process and they felt that they had only limited influence on this process. As result of this configuration the performance of the

\(^\text{81}\) End-users, project owners and delegates of Rijksgebouwendienst.
5. Requirements management in practice

process is not safeguarded and the Rijksgehouwendienst should manage this process more from their experience of construction projects.

A result of this need to satisfy the clients and end-users was found in the 2 of the 3 projects in which the empowerment of the end-users was realized by giving them the responsibility to write in the OS document itself. In the Defensiemuseum project for example, this was the case despite the fact that the delegates found it “difficult to write the performance specifications while they normally have a clear understanding on their requirements towards a project but in the context of a DBFMO project this requires a different approach.”

They had no prior experience with performance requirements or PPP projects and were not able to formulate the substance required in the OS document. As a result, this responsibility was transferred back to the coordinators of the OS team, thus the delegates of the Rijksgehouwendienst. In comparison, in the process of the Hoge Raad project a different, clear differentiation and separation in the roles of the experts – Rgd and project owners – end-users was established. The roles in this project were defined in such a way that the end-users were given the responsibility to provide the information required by the various abstraction levels of the OS document and the professionals of the Rijksgehouwendienst and PHD (project owner) – who have prior experience with the performance of a construction projects – used this input for the formulation of the substance of the OS document. As this is an example of another approach, the respondents indicate that this clear delineation of the responsibilities and a clear management of the process establishes a more suitable structure in the process which significantly influenced the performance of the process in a positive way.

As the previous observation is related to the importance of a clear differentiation of roles for the end-users, project owners and delegates of the Rijksgehouwendienst, it is observed that multiple respondents of the different projects question the role of the experts of the Directie Advies & Architecten in the process. These experts are used in 2 of the 3 projects to formulate the substance of the different Trees in the OS document and thereby the required performance specifications. As the first variables in this chapter indicated a lack of knowledge on the concept of DBFMO, it is learned that the experts of this directorate find it difficult to accept the workings of the DBFMO concept and therefore formulate the specifications in a very tradition, solution-oriented manner. As a result the role of these experts is varied in some of the DBFMO projects, but not in a structural manner.

“Delegates of the Rijksgehouwendienst in DBFMO projects tend to give responsibilities away to their clients in the process (as they are the managing party). This is a result of the fact that many participants in the process (both Rijksgehouwendienst but also other stakeholders) have never performed such a process and are discovering a suitable approach. However, I believe that – in order to perform this requirements management process properly – the Rijksgehouwendienst should use a structural approach so that roles and responsibilities are managed properly.”

Respondent N

82 Stated by respondent Respondent V – delegate of one of the end-users in the Defensiemuseum project
83 In the Hoge Raad projects this responsibility was totally transferred to the AV’er of the Rijksgehouwendienst who was responsible for the formulation of the OS document and used the experts as advisors.
84 Experience of team with the process
“There is the culture within the Rijksgebouwendienst to create a harmonic process with the stakeholders. However, I think that the requirements process requires from the delegates of the Rijksgebouwendienst to take “charge” in this process since we are the experts on housing projects.” Respondent G – OS team coordinator for VR8 DBFMO.

“One important lesson learned from the performance of the requirements management process was that it requires an more structural organisation in which the delegates of the Rijksgebouwendienst should make more effort to guide the process and act more as an expert of housing project instead of increasing the responsibilities of the end-users who have never worked with an output-specification or performance requirements before. Respondent F, OS team coordinator of DBFMO Gerechtsgebouw Breda.

“In the current practice of DBFMO projects it can be observed that the Rijksgebouwendienst “easily” gives responsibilities to delegates of their clients. The Rijksgebouwendienst as procuring agency should act more strict in this process and safeguard the process instead of willing to satisfy the other stakeholders. (...) The roles and responsibilities of all stakeholders should be defined more clearly and this also means that the role of the client/end-user should be limited according to the requirements of the process.” Respondent F on the importance of a clear definition of the roles of stakeholders and the importance for the Rijksgebouwendienst to actively manage the process.

“We choose to create a clear differentiation in roles between the end-users and the experts – Rgd and PDH – in the requirements management process. The end-users were given the role to provide input on their requirements and when we had a clear perspective on their goals and ambitions the functional and performance specifications were formulated by us (the Rgd). This resulted in the fact that this process could be performed more efficiently and the discussion was performed on a high abstraction level and not on the performance specifications. This is a desired situation since the end-users mostly have no knowledge on the concept of performance specification.” Respondent B on the clear differentiation of roles in the Hoge Raad project.

Difficulty of inexperienced stakeholders to accept boundaries of responsibility

Closely related to the clear definition of the roles and responsibilities of the different stakeholders, is that inexperienced participants in the process found it difficult to work within the pre-set boundaries of their given responsibilities. The factors which influence their adequate performance of their role in the process is presented in figure 19. Some of the delegates of the different end-users find it hard to accept their role in the process and want more control. These delegates tend to have a different perception on their responsibility and role in the process. This is a factor which significantly influences the performance of the process and the quality of the output when not properly managed. In the Hoge Raad and/or DUO/Belastingdienst projects the delegates of the end-user wanted – as result of their limited perception on the concepts of DBFMO and performance-based briefing or their aim for control on the end-product – to force the specification of a certain solution instead of providing information on their actual requirements. They perceived the latter as insignificant in the achievement of their pre-set goals and were heavily focussed on the integration of their solution-oriented specification in the OS document.
The delegates of the Rijksgebouwondienst have the responsibility to create a process environment in which clients have clear perception – and acceptance – of their role in the process, the function of the performance specification in the DBFMO context.

“It is important that the participants of the clients and project owners realize their role and the consequences it brings when they work outside of their responsibilities. It is important that delegates of these stakeholders are selected which can perform and respect these roles. However, the Rijksgebouwendienst has to increase their stakeholder management in this process so that these stakeholders are participating in the process and participating in a suitable manner.” Respondent E – AV’er for the Hoge Raad project.

“Due to the limited experience of the end-users with the process, and the fact that they only perform this process one time it happens that they step out of their role in the process. They want a certain performance specification or solution to be integrated in the OS document and force the OS team to accept this.” Again Respondent E.

“We noticed that the delegates of the end-users in the project-team had allot of questions and remarks on the substance of the OS. Before the start of the process it was decided that the OS team and the placed delegates of the end-users were responsible for the substance but in practice this was not safeguarded. These delegates of the end-users wanted to influence the process after the decisions were formalized which influenced the progress and quality of the OS document.” Respondent F on the limited acceptance of roles by the delegates of the end-users and its consequences.

Influence of decision-making structure and level of mandate on process

All of the projects studied are characterized by the hierarchical organisational structure or the project organisation. The hierarchical structure of the governmental organisations involved is transposed to the project organisation of the DBFMO projects. It is observed that the decision-making structure in the hierarchical organisation can influence the process and progress of the requirements management process if not managed properly. The case studies provide two “extremes” in relation to this subject. For the Defensiemuseum, the members of the Steering Committee where given the formal position to provide decision-making on the significant subjects as museum collection, museum presentation concept, ambition document, project definition and scope of project. As a result, the OS team was highly dependent on the progress of this Steering
Committee to provide formal decisions which on its turn was dependent on other project organisation which provided the information on these subjects. The result was that the lack of decisiveness of the top of the hierarchy in combination with the delays caused by a lack of progress by some of these projects groups negatively influenced the progress of the OS team. The cause of this lack of decisiveness is not subject of this research project but more important is the fact that the conclusion that the establishment of a hierarchical project organisation can be of significant influence on the progress and quality of the performance of the requirements management in a PPP project.

The other “extreme” is found in the project of the Hoge Raad which indicated that in an hierarchical organisation it is of significant important that the level of mandate of delegates of stakeholders in the OS team is properly organized to increase the efficiency and effectiveness of the decision-making process. The case studies learned that the process benefits from the participation of delegates who have significant support within their organisation and have a level of mandate to make decisions. This is observed to have work effective in the Hoge Raad project were an delegate of the Hoge Raad represented his organisation in the OS team and was given an significant level of mandate which resulted in the fact that decision-making was performed more effective than in comparison with for example the Defensiemuseum. In the latter project it is observed that decisions were often altered were as in the Hoge Raad project they were “ever discussed but never contested”. This delegate of the Hoge Raad – who had an high hierarchical position in the organisation – also had an significant level of trust and support within his organisation which he used to create internal commitment and support for the project and – by creating the user groups – this resulted in an high information input of the organisation in the requirements management process. In the Defensiemuseum it is observed that the level of mandate of the delegates in the OS team was not always properly defined which resulted in a certain level of non-decisiveness in this team.

“It is of significant importance for the efficiency and effectiveness of the requirements management process that people participate who have an significant level of knowledge and information on their organisation and its processes; time; money; and a certain level of mandate and support within their own organisation.” Respondent F

“The process was characterized by the fact that the delegates of the end-users had no internal support related to the decisions that they made during the process. In addition, the process – and thereby the project organisation – lacked a defined decision-making structure and the formalization of the mandate of the participants within their organisations. As a result it is perceived that the process lacked decisiveness which resulted in an “drifting” process in which decisions were frequently altered.” Respondent Q

“I was provided an relative large mandate which resulted in an effective and efficient decision-making process in the requirements management process related to the output-specification” Respondent R

“It is important that the delegate who represents the end-user(s) in the process has knowledge on the process (both internally as on the DBFMO process) and has a significant level of mandate and support in his organisation. This means that he as an decision-making authorization and can make qualitative statements which are required in the

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85 Comparison is based on the valuation of the performance expressed by the respondents in the interviews
OS team. This influences the process in a positive way but it is frequently observed that the delegates have no – or an ill-defined – mandate and this means that decisions are altered frequently.” Respondent A

“The project organisation is comprised of the Steering Committee, Project Team and the different teams on operational level. In some cases it is observed that a Procurement Team is placed between the Project Teams and operational teams to guide their process. These teams are provided with different responsibilities and mandate in the process. As a result it is observed that decision-making on specific subjects is performed on multiple levels and it can occur – as is also observed frequently - that an higher level team changes an decision made in an earlier stage in the process.” Respondent G

“In order to perform the process properly it is important that the delegates of the end-user have a significant level of mandate and support of the organisation.” Respondent P on the importance of mandate given to the delegate who performs the responsibility.

“In the process there was one delegate of the Hoge Raad which was the representative of the organisation. This delegate held an important position in the hierarchal structure of the end-user, was given mandate and had allot of support within the Hoge Raad.” Respondent E on the importance of mandate.

“The end-user is represented by multiple - high placed - delegates. One of them had a significant level of support within the organisation. These delegates would interact internally with their adherents and this was also identified as their responsibility which they would require to manage properly.” Respondent B on the importance of mandate and trust given by the organisation to the delegate.

5.1.5 Variable 4 – Consideration of multiple perspectives

When performing a requirements management process it is of importance to acknowledge that due to the complex nature of real estate, massive information in different forms and from different perspectives co-exist. As with the stakeholder management, it is observed in the three exemplary projects that no clear structural method for integration of multiple perspectives of the stakeholders is used to deal with this complex information. It is even questioned whether the Rijksgebouwendienst acknowledged the importance of this complex information as limited use of valuation or analysis techniques is observed. Only limited attention is given to the performance of a substantive problem definition; stakeholder analysis; and the process of identification and analysis of requirements from multiple perspectives in one stakeholder. On the latter the respondents indicate that the process lacks a structural analysis of the input of the stakeholders. No consequent analysis of objectives, goals, ambitions and requirements is performed when input is provided. For each of the three projects a different method is used which should safeguard the level and quality of input from the relevant stakeholders participating in the process. For example, in the Hoge Raad project it was the delegate of the Hoge Raad itself who initiated the use of user groups to increase the support for the project and to increase the quality of the information input in the requirements management process. In the Defensiemuseum project, the responsibility for safeguarding the information input by the end-users

86 Which is acknowledged by multiple observations taken in different project teams in which I was active during the internship.
organisations was transferred to the project owner and the end-users only were given a small role in the project organisation in the providence of information.

As stated, in the Hoge Raad project there is made and significant effort to incorporate the organisation of the end-user in the process and to create a process in which the sub-stakeholders who make up the “Stakeholder” – as is displayed in figure 20 – are integrated in the process. The importance of consideration of multiple perspectives in the Hoge Raad project is acknowledged and multiple techniques are used\(^{87}\) to increase the perception on the needs and desires of different groups in the organisation. It is learned that delegates of the end-users find it difficult to perceive the project from an organisational perspective instead of their individual preferences. Caused by the lack of experience of these delegates on the performance of an DBFMO project; the related requirements management process; and the concept of performance specification it is observed that delegates of the end-users frequently approach the process from an individual perspective instead of collective organisational perspective. This is perceived as an important challenge which needs to be managed properly since the delegates must be guided to represent the organisation instead of their own preferences which not always match. Despite the fact that the use of these user groups was initiated by the Hoge Raad itself, it is observed that this positively influenced the process and the gathered information as compared to the other two projects. A positive side-effect of the creation of these user groups was the increased support by the employees of the Hoge Raad and the delegates in the project organisation since they had the feeling that they had a certain level of influence and control on the process.

As to the positive experience in the Hoge Raad project it is observed in the other two projects, Defensiemuseum and DUO/Belastingdienst, that the integration of multiple perspectives was performed in a different manner. As the differences of these projects compared to the Hoge Raad project is found in the fact that the latter only integrates one stakeholders, the Defensiemuseum and DUO/Belastingdienst project organisation comprise of multiple clients for of the Rijksgebouwendienst. This has a great influence on the manner of consideration of multiple sources for information in the requirements management process. In the Defensiemuseum project it is observed that in the initial phases the end-users only obtained a limited role in the process as the team coordinator of the Services and Facilities team stated that “this team only existed on paper. I represented the two end-users in this team and interacted with the two museums when I needed specific information on these subjects.” As a result of this distance between the project organisation and the end-users, the commitment and providence of information decreased over time. Research on the archival data

\(^{87}\) For example the interviews and user-groups.
learned that it is multiple times acknowledged by the coordinator of the OS team that the lack of participation by the end-users formed a cause for concern as there was a delay of provision of information by these end-users. Due to this resistance the project organisation decided to give the end-users a more active role to safeguard the progress of process.

As with the Hoge Raad and Defensiemuseum project, in the DUO/Belastingdienst project a different approach was selected as the facility service of the Belastingdienst – B/CFD – obtained a central position in the provision of information on the requirements and wishes towards the DBFMO project which was to be integrated in the OS document. The process manager of the Rijksgebouwendienst stated its concern on the central position of this service in the process and the limited participation from the organisation itself. However, the director of the Belastingdienst didn’t support this and therefore this is kept unchanged in the process. As with this central position of the B/CFD it is observed that the second end-user – DUO – only had a limited role in the process as B/CFD had more experience with real estate projects and this was used in the approach to formulate “one” perspective towards the real estate project and the facilities and services that are to be provided. The input and requirements of the Belastingdienst were used as a based and the input of the DUO was reflected on this. As a result, the DUO desired to have more control on the process due to their position in the periphery of the requirements management process.

“I think the objective of the process has to be that nobody is excluded of “lose sight” of it. This will cost allot of energy but in the end it will increase the user satisfaction because these stakeholders will be the users of the building.” Respondent W of the Hoge Raad who initiated the use of user groups in the requirements management process.

“Respondent W came up with the idea to form user groups within the organisation with the goal to create support towards the project and to create insight in the preferences of the members of the Hoge Raad. This was a good action as it increased the quality of the input and thereby the formulated requirements towards the project.” Respondent S (OS team coordinator) on the initiated user groups.

“In different levels of the project organisation there were different delegates and members from the end-users. A central position was given to the B/CFD which formulates the housing policy of the Belastingdienst and these had multiple delegates in the OS team but also in other levels of the project organisation.” Respondent AA on the central position of the B/CFD in the DUO/Belastingdienst project.

“The Belastingdienst – and primarily the B/CFD – had more experience with construction and facilitation of services of real estate than compared to the DUO. The requirements on real estate concepts of the Belastingdienst were used as a basis to reflect the input of the DUO.” Respondent AA on the limited role of the DUO in the requirements management process.

“In the process it is very important to have a intensive interaction with the end-users next to the fact that they provide input in the process. An important mean is the use of user groups in which delegates of the end-users have the possibility to discuss important topics in the OS document. This is a good mean to integrate the end-users in the process, to get a clear perspective on their requirements and thereby to decrease the resistance towards PPP.” Respondent O on the importance of an active integration of the stakeholders in the process.
Lacking traceability of input of stakeholders

The preceding findings indicate how end-users and clients are integrated in the project organisation and process. The user groups, interviews and excursions are some examples that are used to create a complete image on the information required for the OS document. However, during the internship and analysis of the projects it is observed that the Rijksgebouwendienst lacks the ability to document the provided input in a central requirements document in which the analysis of the information input and evolution of requirements over time is documented. It must be acknowledged that a suitable IT system can increase the capability of the Rijksgebouwendienst to increase this structural documentation. At this moment, the employees of the Rijksgebouwendienst indicate – and this is observed in practice – that the documentation system is not capable to cope with a dynamic document database. Respondent W who initiated the user groups for the Hoge Raad indicated that he – and the employees – questioned if the output of these groups were actually used as input for the process since no clear documentation and evolution of the information used for the formulation of the OS document could be provided for by the delegates of the Rijksgebouwendienst. As a result of these lacking communication and documentation, commitment was stressed and it required allot of energy to keep the trust and commitment to the process. However, even when this energy is provided it is observed that the user satisfaction was highly influenced by the level of recognition the stakeholders have with the substance of the process. If they can identify with the substance in the OS documents – the goals/objectives/requirements – and they feel that they can influence the process then this positively influences their satisfaction which – on its turn – increases the commitment and cooperation to the process.

"The output of the user groups was initially aimed to be used as input for the formulation of the objectives and goals integrated in the OS and ambition document for the project. However, as a result of the limited documentation and translation of the output of these sessions this was not formalized in the process and used in the formulation of these documents." Respondent R on the limited structural integration of end-user input in the requirements management process.

5.1.5 Variable 5 – Methods used for collection of information

In the requirements management process it is expected that the delegates of the stakeholders active in the process don’t have allot of experience with the performance of an real estate project. It is observed that these delegates find it difficult to state the requirements for the organisation towards the new real estate. This is the result of multiple factors, namely the length of duration DBFMO contract; influence of political context on organisation and project; lack of knowledge or experience on performance of real estate projects; and difficulty to imagine performance of business processes in new real estate context. Therefore, it is the responsibility of the delegates of the Rijksgebouwendienst to create a process in which these delegates can provide clear information on their requirements and wishes. In the DBFMO projects a variety of methods are used to collect the right information from these stakeholders as is shortly addressed in the previous variable and will be further discussed for this section. These methods can be categorized by active methods in which the delegates of the Rijksgebouwendienst actively interact with the client to derive information; and passive methods which
relate to the use of standard document which need to be provided by the end-users and clients of the Rijksgebouwendienst to be integrated in the process.

Collection of information in DBFMO projects by requirements “trawling” techniques

For the active methods, it is observed that the performance of this requirements “trawling” is done without an available structural framework and in an ad hoc manner which doesn’t integrate analysis and valuation techniques. This ad hoc manner is dependent on the knowledge of the responsible delegates on the concept of requirements in relation with the formulation of performance specification in the output-specification. The analysis of the Hoge Raad project indicated the acknowledgement of the different types of requirements as discussed by Robertson (2001). The OS team performed significant effort to discover not only the conscious requirement but also the unconscious and – however only partially – the undreamed requirements. By means of multiple techniques as excursions, multiple user groups and sessions with experts of the Rijksgebouwendienst the OS team tried to decrease the number of constraints of the participants and increase the perception on the real requirements. However, this effort is not perceived in the other projects. Therefore, it is observed across these projects that the use of requirements “trawling” techniques and the effort performed in this process is dependent on the delegates assigned to the OS team and their perspective on the importance of this subject. The process of identification of requirements – or requirements engineering as referred to in the Systems Engineer framework – is perceived to have a significant influence on the user satisfaction due to the identification of their “true” requirements towards their future real estate. In addition, it is perceived by the author that this is an element on which more attention must be given to increase the application of such techniques to identify the different types of requirements. This is the responsibility of the delegates of the Rijksgebouwendienst as the end-users and project owners only have limited knowledge on this concept. However, it is already observed that only limited tools are used for the analysis and collection of information.

“The end-users mainly provided input which was mainly solution-oriented. This input was not integrated in the process or in the OS document because this may not comprise of any solutions.” Respondent E on the limited translation and use of solution-oriented input from the inexperienced stakeholders.

Collection of information in DBFMO projects by documentation

As with the use of these active methods, the methods used for the collection of information from the stakeholders is also collected by documents which are to be formulated by the project owners and end-users. Two examples of important documents are required to formulate are the Design Specification (in Dutch: Plan van Eisen) and the Ambition Document. The first one integrates a spatial and functional description of the desired situation which is to be realized. The latter integrates a description of the goals and objectives of these stakeholders towards the projects. It is observed that the use of these documents and their substances varies

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88 The respondents found it difficult to indicate how they collected the tacit knowledge and information they required since they have only limited knowledge on the different types of “trawling” techniques and types of requirements.

89 For example an objective analysis as output of the stakeholder analysis to create a full perspective on the objectives for the project. This can provide a first step in the formulation of the Output-Specification since the top level requirements consist of these objectives and goals.
over the projects but they are perceived to influence the performance of the process. An important influence relates to the premature formulation of these documents – or when the projects are formulated without clear perception and knowledge on the DBFMO and PPP concept – by the stakeholders before DBFMO is selected as mode of procurement. For the projects of the Hoge Raad and DUO/Belastingdienst it is observed that the preparation phase – in which these documents are formulated without any structural guidance of the Rijksgebouwendienst – is not performed with the concept of DBFMO in mind.

As a consequence, the perception and attitude of the stakeholders towards the real estate, project and process is not in line with what is expected from them in DBFMO projects. This comes from the fact that these documents are perceived to be formulated from an “traditional” perspective and thereby creates a certain expectation by the clients and end-users which can influence the performance of the process and their satisfaction with the process and the project. Reflecting this observation to interviews conducted in the context of other DBFMO project reveals that the suitability of the formulation of the Design Specification is questioned. Respondent K – head of department Sustainability & Comfort of Directie Advies & Architecten - stated that “It is undesirable that the end-users and project-owners create a specific image of the result of the project when formulating the Design Specification and this is changed over time or by the fact that an DBFMO agreement is used. This should be managed in an early stage of the process to safeguard user satisfaction.”

“The end-users and clients has to use the Design Specification document to specify which rooms they require as result of the project.” Respondent F on the methods used for collection.

“As result of the formulation of the Design Specification and Ambition Document, the project owner and end-users had a very clear idea on how they wanted the museum to be constructed and exploited. They knew to well what they wanted and we needed to overcome this by explaining the principles of PPP and making clear that they could not provide any solution in the OS document.” Respondent D on the influence of the formulation of a Design Specification and Ambition Document by the end-users without guidance of the Rijksgebouwendienst.

“The Ambition Document wasn’t completed when we started the process for formulation of the OS document. However, another source of information was used as input in this process, the Design Specification. We perceived it as strange to start with the formulation of this document since this is performed from an solution-oriented perspective. The formulation of this document resulted in the fact that the end-users have a clear expectation towards the result of the project and find it difficult to change this as is required by the DBFMO concept.” Respondent R on the influence of the formulation of the Design Specification.

5.1.6 Variable 6 – Knowledge on formal procedures of process
When performing a project or process it is expected that the responsible delegates of the Rijksgebouwendienst have a clear perception on the tasks that are to be performed and the methodology they should apply in order to fulfil the quality objectives formulated for this projects and processes. However, the quality management system of the Directie Projecten – which has an ISO certificate – lacks any clear description for the performance of processes required to be performed in a DBFMO projects. This ISO9001 certificate states that the quality system is up-to-date and integrates the quality objectives for the projects performed and guidelines for the required processes. Despite the certification of the Directie Project, no formal process description could have been provided for the requirements management process and formulation of the OS document in DBFMO projects. Additionally, no quality objectives are formulated or documented for the output-specification document. As is already mentioned before, this is a possible result of the limited knowledge management performed in the directorate which lacked the formulation of a sort of “best-practice” for the performance of these projects and the requirements management process. It is acknowledged that the management of the process requires degrees of freedom for the professionals, but some guidelines and information are required when a process manager or OS team coordinator start with the project. Interviews with for example Respondent A; Respondent L; and Respondent Q acknowledged this observation. It is observed that the knowledge base on the performance of the requirements management process lacks some sort of standard process or guidelines which team coordinators or process managers can apply to manage or steer the requirements management process.

It is acknowledged by multiple respondents that there is no known approach or methodology for this process or some sort of standard process description. This also relates to the application of the Nordic Five-layer structure which is presumed to be the methodology or standard used in DBFMO projects to formulate suitable goals, objectives and performance specifications. Respondents responsible for the management of the requirement management process had only a partial perception on the application of this concept and thereby the process which is required in the performance-based briefing. In relation to the use of the Nordic Five-level structure it is observed that for the Hoge Raad and Defensiemuseum the respondent stated that they applied this approach by “working from an high level (objective) to lower levels (functional and performance specifications)” or “Worked from an high to low layer in the pyramid.” Now it is perceived that the processes are performed based on personal perception, knowledge level and preferences instead of applying the concepts of the Nordic Five-level structure in a structural manner. In some DBFMO projects the OS team directly begins to work in the OS document without having any knowledge on the goals, ambitions and high-level requirements of the stakeholders. This lack of a structured methodology to work with the concept of performance specifications has a significant influence on the quality of OS documents formulated; the consistence of different OS documents; and the level of detail integrated in this document.
Another observation in the application and performance of the formal methods is the limited application of the concept and the analysis of the information-input on the requirements of the stakeholders. Respondent N stated that the application of the Nordic Five-level structure was only limited and mostly the essentials of the theory were not applied. The respondent mentioned that it is perceived in – for example – the identification of the objectives or ambitions of the stakeholders no structural objective analysis or prioritization is applied. On the lacking structural objective analysis, it is observed that the respondents indicated to have trouble to formulate clear and unambiguous objectives which are relevant to all of the stakeholders in the project. Mostly, the objectives are copied from the ambition document without having a clear perception on the functional and performance requirements towards the project. In addition, the lack of prioritization in this objective analysis can result in the fact that an output-specification is formulation in which everything is perceived as important which gives a minimal guidance of the private consortia. This requires the OS team to steer the information requiring process in such a way that it obtains statement of the relevant stakeholders on the prioritization of these objectives, goals and ambitions. These indicate the elements which determine the eventual success of the project, but as is observed during interview and review of the DBFMO document of the projects – and specifically the Hoge Raad projects – it is observed that the integration of these CSF’s is lacking in the process of the projects studied. It is observed that the application of the Nordic-Five level structure – and use of prioritization of requirements in form of CSF’s – is only performed partially. Reflecting this statement on the interviews performed aside of the interviews conducted for the case studies is used to refine this statement.

Another observation made in this context related to the fact that the projects lack a structural approach to determine the level of detail of the specifications and how these are transposed from the related objectives. The respondents for the three projects are asked to describe the approach they used to determine the level of detail they formulated in the output-specification. However, as is also observed in the archival research, no respondent could indicate a method or approach they used in the functional specification for the OS document. A significant amount stated that they specified an “high level of abstraction level possible to stay out of solution-oriented approach” or “we specify the specification on an detail level in such a way that we are sure that we don’t get what we don’t want.” However, as is also the core of the PPP concept as the literature study identified, a central concept which can be used to specify this level of detail is by assessing the risk related to these specification. It is observed that no structural integration of risk, clear functional decomposition and requirements engineering in the specification of the performance specifications – or in the whole requirements management process – is structurally integrated.

“The problem occurs that the risks are identified for the entire process but for the output-specification this is neglected. No relations are perceived between the high level statements – goals and objectives – and the functional and performance specification. The problem is observed that everybody states to specify on the “highest level”

90Who is perceived to be one of the employees of the Rijksgebouwendienst who has a significant level of knowledge on the performance of the requirements management process in relation to the application of the Nordic Five-level structure. For more information it is referred to (Zeegers & Ang, 2003) or (Zeegers & Ang, 2007)
91Acknowledged by Respondent X; Respondent R and in multiple conversations during the internship
possible but it can be questioned what this is and if this approach don’t integrate solutions in the specification for example. A more suitable approach should be the use of functional decompositions of requirements and the use of risks in the specification of requirements. This means that you use an high abstraction level for an specification when you assess that the risk can be best managed by the private consortia for example’’ Respondent X on the lack of knowledge on the substance of the Nordic Five-layer structure

“At this moment – during the performance of the OS stage – we didn’t performed any effort to identify CSF’s for the project. This is planned to be performed but, however, this shall be performed for the whole projects and not specifically with the purpose to be used in the output-specification. We assumed that the goals and objectives integrated in the Ambition Document are sufficient for the start of the requirements management process and that they give a good reflection on the preferences of the end-users. The use of CSF’s in the process related to the formulation of the output-specification is not a standard approach for this process.’’ Respondent G

“No applicable framework can be identified which can be used during the formulation of the performance specification in the OS document. In this project I tried to define the abstraction level on my “feeling” and experience. However, for this project it was perceived that it was impossible to use the concept of functional and performance specifications in order to steer the consortia in the right direction. In order to safeguard the fact that the result meets our standards and requirements we decided to integrate a significant level of solution-oriented specifications.’’ Respondent F on the lack of a applicable framework for the formulation of the performance requirements.

Influence of digital OS model on formal process used

Although the requirements management is characterized as a process in which the Rijksgebouwendienst interacts and cooperates with stakeholders in a DBFMO projects, the digital model which forms the backbone of the OS document is observed to play an central role. Despite the fact that this model is perceived as an mean in the process for the three projects the structure and elements of the digital model determines the used approach in the process. In essence, the model integrates the different levels of the Nordic Five-level structure which are essential in this process. These are the goals and objectives (first two layers); functional specifications; performance specifications and verification methodology. The backbone of the model is the Spaces Tree which describes the spaces and rooms which are needed to be realized in the real estate by the private consortium. However, it is observed that the structure of this digital model has significant influence on the performed process. It is even observed in the projects that the Spaces Tree was specified before the ambitions, objectives and goals were clearly formulated and formalized in the decision-making structure. This can be performed to a certain level, but the risk must be acknowledged that when goals; ambitions and objectives of the stakeholders change or are not initially defined properly this influences the functional and performance specifications.

Multiple respondents92 of the three different projects identified the desire to approach the requirements management process from an process-oriented perspective instead of an spatial orientation. Respondent G stated that it the process is performed in a more accurate manner if one integrates the processes performed by

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92 For example Respondent L; Respondent G; Respondent N; Respondent R; and Respondent A.
the organisation as a central element instead of neglecting this characteristic. Currently this is perceived to be an experimental approach in the requirements management of the Rijksgebouwendienst and the process is still – however heavily discussed within Directie A&A – performed from an spatial-perspective instead of an process-perspective.

As is stated by multiple respondents – in the case studies; in meetings and observations – the OS document and digital model should be a means to an end. The means should be that it enables the Rijksgebouwendienst to communicate the ambitions, requirements and performance specifications of the project to the private consortia. However, it is observed that the model currently is a determinant for the selected process. However, it should be done in such a way that the responsibilities are separated – front-phase definition of stakeholders requirements; and formulation of requirements in digital model as mode of communication – but due to the model and the dependence of the participants on this model this is not performed appropriately.

“In our project we have put allot of effort in making a process description of the organisation of the end-uses which we wanted to use as a basis for our output-specification document. In this way the consortia can obtain an clear perspective on the processes which are needed to be performed in the real estate instead of the rooms they should provide. However, it is not expected that this can be integrated in the digital model because this is not the approach of the model. In our team therefore we observe that the model – with the Spaces Tree as backbone – determines the process instead of the other way around which would is preferred.” Respondent L

5.2 Discussion and Analysis

The previous paragraph presents the findings on the six variables identified for the requirements management process. As this is a discussion of the empirical findings, this paragraph reflects these findings on the theoretical foundation of Chapter Three. The perspective of the research project was established by the variables, propositions and predicted causal relations defined in the theoretical framework. From this initial perspective the empirical data is assessed and in this light, several issues have been presented in the previous sections which lend weight to the propositions and variables. This is performed by comparing the observed pattern from the DBFMO projects with the predicted pattern described in the academic knowledge-base. This comparison provides insight in the relevance and shortcomings of this knowledge-base; the validity of the findings; and enables the identification of strengths and weaknesses of the practical performance of the process.

5.2.1 Variable 1 – Experience of team with process

The analysis of the case study confirmed the importance of the level of experience of the project organisation with the performance of DBFMO projects and performance-based briefing. This variable is further conceptualized as it can be related to the level of acceptance of the DBFMO concept; knowledge on required processes in requirements management process; and knowledge on substance of performance-based briefing concept. The framework predicts that the experience of the delegates of the project organisation will improve the performance the process, as this influences the performance of the process on several ways. The case study indicated the importance of a significant level of experience of the delegates in the project team. For
delegates of the Rijksgebouwendienst it was perceived that they had only limited experience with the performance of this process in the context of a DBFMO project and the primary result is that the delegates used experiences and knowledge derived from traditional procurement project to influence their performance in the cases. As a result, the performance of the process and the formulation of of the OS document are questioned. The observations provide proof which indicates that it is not only important that delegates of the project organisation of the Rijksgebouwendienst – AV’ers or experts from Directie Advies & Architecten – are experienced with the requirements management process, but also accept the DBFMO concept and its elements for the qualitative performance of this process.

As this discussion relates to the delegates of the Rijksgebouwendienst in the project organisation, the exemplary projects also found proof for the importance of experienced delegates of end-users in the performance of the process. It is predicted that the level of experience of the delegates determine their ability to define their requirements. It is found that the inexperienced delegates in the OS team, interviews and user-groups found it difficult to provide information form a collective perspective and mainly formulated this form an individual perspective. This confirms the predicted relations, but it can be expanded by the observation that the experience of the delegates influences the level they are able to accept and work within the boundaries of the responsibility. Examples are found in the case study of delegates who – as a result of their inexperience and limited acceptation of the use of DBFMO as mode of procurement – negatively influenced the process as they wanted to obtain more control on the process and substance of the OS. This is discussed in the context of variable 3, on the roles of the stakeholders in the process.

5.2.2 Variable 2 – Commitment and Resistance of stakeholders

Using the findings of the case study it is perceived that the definition of the variable and proposition is limited and can be extended in the context of DBFMO projects. Initially, it is predicted that a high level of commitment of the stakeholders will improve the performance of the process. This primarily is predicted to be the result of active participation of stakeholders; promptness of decisions-makers; and support from top-management which determines the quality of information during the process. The study is used to acknowledge these elements and the importance of commitment of stakeholders towards the process. One element which needs to be considered in relation to this variable – and which is not discussed extensively in the theoretical framework – is the influence of the hierarchical structure and the decision-making process in the project organisation of a DBFMO projects. It is confirmed that a lack of commitment to the process can result in the fact that the decision-making process is slowed down and the progress of the requirements management process is decreased – both qualitative and over time. Therefore, the causal relation of the variable is not only acknowledge by means of proof provided by the cases, it is also extended by identifying how resistance or commitment can influence the performance of the process; and how the organisational structure of DBFMO projects influences this process. On this resistance, it is learned that it is of importance that incentives are created for the stakeholders so that they cooperate in the projects. This is defined in the literature on process management as the “the need for a sense of urgency.” (de Bruijn, ten Heuvelhof, & in ’t Veld, 2002) This means
that the stakeholders must be convinced that the requirements management process is performed to serve their interest and problems, and that it is in their best interest to actively cooperate in the process.

The theoretical framework is extended by identifying potential sources of resistance of stakeholders towards the process. It is of significant importance that these are acknowledged in the practical performance as founded resistance can decrease the qualitative performance of this process. The hierarchical decision to use DBFMO; the lack of knowledge of the stakeholders with DBFMO and concept of performance-based briefing; and the limited identification of the end-users with the process and substance are perceived to be the main sources of resistance towards DBFMO projects. As result of the lack of knowledge of the stakeholders – clients and end-users – with the DBFMO and performance-based briefing concepts; they assume to have little control and influences on the process, design and project. Whether this can be justified in the process, it is the responsibility of the delegates of the Rijksgebouwendienst – which are perceived to be the process architects – to manage the process such that it is open and protects the stakeholders’ core values (de Bruijn, ten Heuvelhof, & in ’t Veld, 2002). Openness means that the Rijksgebouwendienst does not take unilateral decision but provides room for other stakeholders to participate in steering the decision making. At the same time it requires the process to be transparent so that the stakeholders have a clear perspective on the course of the process and how their interests are protected. Protecting the stakeholders’ core values means that the requirements management process should be managed in such a way that the parties joining the process are able to influence the substance of the process instead of creating the feeling that they are in a funnel trap. As the case study identifies a significant level of resistance towards the projects in terms that stakeholders feel that they are not able to influence it properly, it is questioned whether these values are properly managed in the current practice of DBFMO projects.

5.2.3 Variable 3 – Roles of stakeholders

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. No consequent stakeholder management is observed as the delegates of the Rijksgebouwendienst find it difficult to balance between “satisfying the client” and “managing the process properly.” In retrospect, the progress of the process is negatively influenced when an inexperienced delegate of an end-user is provided a central role in the OS team which he is incapable to perform. This confirms the theoretical statement that a clear definition of roles to the stakeholders – based on their capabilities, experience and position – safeguards the control of the process and thereby its progress. Despite the fact that no hierarchal categorization can be made based on this qualitative research the importance of the roles and responsibilities of the stakeholders in the process is acknowledged in the case study. The case study indicated that the performance of the process – both in process, organisational and methodology concepts – is highly dependent on both the organisations who participate in the process and the delegates who represent these public organisations in the requirements management process. The role of the stakeholders was perceived in the literature fell short in describing the significant influence of the individual and organisational preferences on the requirements management process.
The initially defined proposition is not only confirmed but several factors are identified for this variable. These can be perceived to be the further conceptualization of the variable. These variables are observed to be the (1) level of structural and considered definition of roles and responsibility; (2) level of acceptation of roles and boundaries of responsibility by stakeholders; (3) level of consequent performance of roles by professionals Rijksgebouwendienst; and (4) level of mandate of delegates of the stakeholders. These factors are perceived to influence the performance of the process in relation to the roles of the stakeholders in the process. As the findings of the cross-case analysis provide an description and examples of the factors, it is important to mention that the level of experience of the stakeholders determine the manner how they perform their provided role in the process as it is observed that the delegates of the end-users find it difficult to work within the pre-set boundaries of their responsibilities and when these aren’t safeguarded the qualitative progress of the process can decrease.

Next to a clear definition and management of the roles of the different participants, the level of mandate of delegates in the process is learned to be an important factor for this variable. This relates to the influence of the hierarchical structure of the project organisation. As the theoretical framework was not concise in the relation of this element on the performance of the process, it is learned in the study for this variable that these elements can have a positive influence on the process if properly managed. De Bruijn & ten Heuvelhof (2008) indicate in their work that “those who only rely, or rely too much, on the formal structure (of hierarchy in an organisation) will not be able to function effectively. However, a wise director also knows that hierarchical intervention can work, if used intelligently.” In theory, in a hierarchy the decision-making is performed in phases and with a regular and sequential character (de Bruijn & ten Heuvelhof, 2008). A top-down and structure approach of the decision-making on the subjects and detail of the subject can be an effective approach for the providence of information input for the OS team when performed adequately. The findings illustrate that this proper management closely relate to the level of mandate that is provided to the delegates in the OS team. When this mandate is not properly managed this can result in a negative influence by the hierarchical structure on the progress of the OS process.

5.2.4 Variable 4 – Consideration of multiple perspectives

The theoretical framework was limited in its description on this variable but the academic works were clear that the incorporation of multiple perspectives from – and within – stakeholders will improve the information input in the process. The analysis learned that the structural integration of multiple perspectives in the process will positively benefit the process, but not only through an increased input of information as the study indicates that this is also influences the process as active integration of stakeholders increases the support and commitment of these stakeholders. This in its turn increases the stakeholders to believe that they can influence the process and therefore is perceived to be a positive feedback loop.

Despite this positive character of the active integration of stakeholders – and different delegates of one stakeholder – by means of user groups, interviews and excursion, 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
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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, An analysis of the requirements traceability problem, 1994) and is not discussed to an significant extent in the literature on requirements management. An requirements is traceable if “(1) the origin of each of its requirements is clear and if (2) it facilitates the referencing of each requirement in future development or enhancement documentation.” In the projects it is learned that the commitment to the process is decreased when the stakeholders don’t recognize the input they have given in the process in the documents or OS model as result of a limited requirements traceability.

5.2.5 Variable 5 – Methods used for collection of information

This fifth variable is used to assess the methodologies that were used in the requirements management processes of the cases to create a comprehensive perspective on the stakeholders requirements for the projects. The study learned that the definition of the proposition was too narrow since it only related to requirements “trawling” techniques which assume active interaction with stakeholders. However, the study learned that in this process of the projects the methods used for collection of information can be categorized in active and more passive methods.

On the use of the requirements “trawling” techniques it is concluded that the proposition could not fully be assessed during the study. In one project it is observed that the project organisation actively used techniques as user groups, interviews, excursion and surveys but no value judgement can be related to whether this increased the perception on their requirements. The use of these projects had a positive influence on the process and providence of information by the stakeholders -- as presented in the discussion of the previous variable -- and thereby it can be expected that this increases the perception on the stakeholders’ perception. However, it is acknowledged at this point that the empirical data on this variable is somewhat limited and it can be expected that more methods are used in the projects but which are not fully expressed by the respondents since they don’t fully realize when these are applied in the process. On the use of passive document -- Design Specification and Ambition Document -- it is learned that their use can negatively influence the performance of the process. This observation is used to extent the initial framework and it is observed that the use of these documents has a relation to the expectation of the stakeholders which perform the formulation.

5.2.6 Variable 6 – Knowledge on formal procedures of process

The last variable in the theoretical framework related to the level of structural use of a formal procedure/process in the performance of the process. The proposition on this variable stated that the use of a structural formal procedure in the process will benefit the performance of the process. The study learned that this can be confirmed in the DBFMO projects of the Rijksgebouwendienst. This statement is based on the fact that it is observed that the current quality system, the performance of the requirements management process and formulation of the substance of the OS document lacks an structural approach. This resulted in significantly different a OS document which is perceived as a negative result. The knowledge development of the Rijksgebouwendienst requires a structural performance of the process -- and application of the Nordic Five-
level – to develop some sort of “best practice”. At the same time this differentiation of output of the process means that the knowledge development of the private consortia active in the DBFMO projects is limited. Therefore, the use of a structural and formal procedure to perform the process not only influences the performance of the process itself, it also influences the learning capacity of the stakeholders and the total quality of the DBFMO projects.

Aside of these statement, it must be mentioned that the limited level of application of a structural process derived from – for example – the Nordic Five-level structure is also the result of the limited knowledge of the delegates in the OS team on this subject and the limited knowledge management in the organization of the Rijksgebouwendienst. This provides an extension of the causal relations between this variable and the variable of Experience of the team with process.

5.3 SWOT analysis for practical performance process

The previous sections discussed the empirical findings and reflected these upon the theoretical framework on requirements management as defined in Chapter Four. As these findings and discussion partially indicate the practical relevance for the Rijksgebouwendienst, this sections aims to increase the perspective on this practical findings by using an SWOT analysis. This analysis tools – mostly used as a structured planning method – is used to evaluate the Strengths, Weaknesses, Opportunities and Weaknesses for the requirements management process. The identification of these elements can be used to identify steps which are to be performed to increase the qualitative performance of this process.

5.3.1 Introducing: SWOT analysis

A SWOT analysis is a methodology for the identification of the Strength, Weaknesses, Opportunities and Threats of an object of analysis. This analysis helps identify the strategic objectives a organisation hopes to achieve with the processes and can help to identify elements which need to be managed properly in order to achieve the stated objective of the process. It involves specifying the objective of the business venture, project or process, and the identification of internal and external factors that are favourable or unfavourable to achieve this objective. The application of this analysis is dependent on the used perspective and therefore it can be used for a magnitude of purposes. Successful businesses, organisations and individuals build on their strengths, correct their weaknesses and protect their organisation, process or product from internal vulnerabilities and external threats. Strengths are the current characteristics of the object that give it an advantage over others; what is done well by the organisation; or what are the strengths of the existing process. Weaknesses are characteristics that place the team, business or project a disadvantage relative to others or the current weaknesses of the existing process. Strengths and weaknesses are perceived to be the current competences and resources that the organisation or individual processes can control which affect their performance and achievement of objectives. The Opportunities are external characteristics or conditions that the organisation can exploit to its advantage and that are helpful to achieve the defined objectives; and the Threats are external characteristics that could negatively influence the performance of the object, product or
process if not properly acknowledged and managed. It is perceived that the Strengths and Opportunities are classified as positive; and the Weaknesses and Threats as negative.

The results of the analysis tool are integrated in a 2x2 matrix which gives an overview of these 4 characteristics. This output can be used to develop strategies and plans for the achievement of the defined objective for the object and to address the issues in the SWOT. Pairing threats with weaknesses can highlight the most serious issues faced by the organisation which is subject of the analysis; conversion strategies can be defined to converse weaknesses in to strengths; or observed opportunities can be used to find advantages by matching strengths to increase the performance of the object.

5.3.2 Use of SWOT analysis for requirements management process

This research uses the SWOT analysis as a tool to identify the characteristics which influences the performance of the requirements management process, both internal/external and current/future. This provides the practical relevance as it uses the output of the case study and discussion to identify the elements which the Rijksgebouwendienst can use, must acknowledge or manage in order to safeguard the qualitative integration, translation and documentation of stakeholders requirements in the OS document in their current and future practice. The position of this analysis in the research is presented in figure 22. This analysis consists of multiple steps as in the first place the output of the case study is used to identify the most significant – as perceived by the author – SWOT items. These are integrated in the SWOT-matrix in order to provide the presentation of these elements. This is then followed by the analysis of this output by means of the coupling and matching of the items to formulate strategies, plans and/or actions which can be used by the Rijksgebouwendienst to safeguard the objective in relation to the qualitative performance of the performance-based briefing in DBFMO projects. These strategies are formulated based in order to take advantage of the S and O; minimize the effects of W and T; and the coupling of SWOT elements as Weaknesses can be inverted in Strengths for example. In addition, practical insight derived from the analysis which is not integrated in the SWOT analysis is used to formulate actions which could be undertaken by the Rijksgebouwendienst to safeguard the qualitative performance and development of the performance of the process in DBFMO projects. In addition, as tool is used to identify organisational elements in relation to the requirements management process, the SWOT-analysis also provides a coupling between the case study and the assessment of the relevance of use of the SE framework in the current practice of the Rijksgebouwendienst. This analysis identifies – for example – weaknesses in the current requirements management practice which could be – from a theoretical perspective – be overcome by integration of SE elements. Chapter Six uses this knowledge to discuss the practical relevance for the SE framework in relation to this process.
5.3.3 SWOT matrix for requirements management process

The result of the SWOT analysis is the basic template and this is displayed in the figure 23. In this template each of the SWOT elements is grouped and formulated. At this point, no categorization on abstraction level – for example the differentiation between the strategic, organisational and tactical level – and/or hierarchy is appointed to these elements. The latter is perceived as one of the risks or shortcomings of an SWOT analysis as this can result in presenting uncritical lists of elements without prioritization, so that insignificant weaknesses may appear to be important weaknesses. This shortcoming is decreased by the extensive empirical and theoretical discussion of the outcome of the process analysis but it must be acknowledged that no hierarchy could be integrated for the SWOT elements. Next to this lack of hierarchy between the items it is acknowledged that the items are formulated by means of generalization and bundling. The risk for this point is that over-subjectivity in the generalization in the SWOT items influences the quality of the SWOT output and that ambiguous and/or vague descriptions are used. This is tried to be avoided at all costs but cannot fully be overcome in this research. However, the clear relation between the SWOT items; empirical data and output of the case study is an indication for a valid formulation of these items. The matrix identifies a broad range of elements which are perceive to influence the current and future performance of the process or the DBFMO projects as a whole – from an internal and external perspective. At this point it is perceived not to be of added value to discuss all the SWOT elements individually as they are already discussed in the output of the case study and in its discussion. More important is the acknowledgement that these elements – in practically the Weaknesses and Threats – have a significant influence on the quality of the performed process and thereby its outcome, namely the OS document. In the study of Barret & Stanley (1999) and Brown (2001) it was already underpinned that this design process show little evidence of rationale as the process – and the output which in case of the Rijksgebouwendienst is the OS document – is characterized being ‘messy’ and ‘jumble of conflicting and confused aims’. It is found in the case study – as is also identified as to be significant elements for the development of the briefing process by Prins et al. (2006) – that the way of thinking or the mindset for the
process must be opened up for proper client designer communication in order to match expectations and objectives with the translation in the reality. Part of the problem for the process of the Rijksgebouwendienst is that the current process performance highly influences this translation and it is perceived difficult to distinguish the fixed and tangible aspects from the still and intangible aspects which are used in the formulation of the OS document. The SWOT analysis is identifies elements which influence this qualitative performance of the process as it doesn’t directly provide any insights on the substance of the OS document but perceives the performance of the requirements management process as a significant factor in its definition. This analysis of the case study and the SWOT items are used — in addition to the discussion of the relevance of the integration of the SE framework in this process — to formulate the conclusions and recommendations for the Rijksgebouwendienst which are presented in Chapter Seven.

### SWOT Analysis

**Strengths**

2. High level of esteem and respect from public organizations by 90 years of management of governmental real estate portfolio.
3. DBFM as innovative, cost-effective, risk averse and time-effective mode of procurement.
4. Experience in use of requirements engineering/trawling techniques in briefing process.
5. High amount of projects — including DBFM — which are performed.

**Weaknesses**

6. Performance-based briefing and requirements management not fully accepted and structurally safeguarded by limited knowledge, knowledge-management and influence of traditional mindset.
7. Lack of formal and applicable description of activities & procedures; quality objectives; guidelines for process; and formulation of OS document.
8. Lack of structural and consequent stakeholder management in process.
9. Limited analysis of information-input, objective-analysis and the prioritization of objectives/requirements.
10. IT systems and capacities of employees not capable to perform effective requirements documentation to increase requirements traceability.
11. Incomplete information and sluggish decision-making process due to hierarchical structure and political context.
12. Limited analysis of information-input by limited knowledge and use of requirements engineering techniques.
13. Discrepancy between development of performance-based briefing and substance of IT systems, as digital OS model.

**Opportunities**

14. Availability of IT system solution for structural documentation management to increase requirements traceability.
15. The use of structured clear delineation of responsibilities can be evaluated in latest DBFM projects (Hoge Raad).
16. Young professionals with limited experience in traditional procurement projects are active within the Rijksgebouwendienst.
17. Use of identification and analysis of business processes of end-users to identify required functions and requirements is newly used in latest projects and increased in popularity.
18. Knowledge on theoretical foundations of performance-based briefing; Systems Engineering; and requirements engineering available — but dispersed — in the organization.
19. Expectation of stakeholders is significantly influenced in early stage of the process when the DBFM project is not formally initiated and the Directie Projecten is formally involved.
20. Positive experience of use of requirements trawling techniques — as user groups — can be used in projects.
21. Providence of mandate of delegates in OS team positively influences the performance of the process.

**Threats**

22. Public stakeholders have limited sense of urgency to cooperate in the requirements management process.
23. Added value of Rijksgebouwendienst in process is questioned.
24. Definition of roles is not fully dependent on capacity and knowledge of delegates.
25. Diversification of performance of process and use of requirements engineering techniques due to high dependency on professional; lack of guidance and evaluative instruments.
26. Performance is stressed by limited knowledge; provision of individual information input instead of organizational; desire to control end-product; solution-driven perspective; and acceptance of roles/responsibilities of stakeholders.
27. Decrease of user satisfaction by limited incorporation of interests and requirements of stakeholders by unstructured requirements management and standardization of housing.
28. Limited development of process performance and applied requirements engineering tools due to lack of structural evaluation and knowledge management.
29. High level of resistance on decision to use DBFM in projects by limited knowledge and fear to lose control.

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**Figure 23 - SWOT analysis for requirements management process of the Rijksgebouwendienst**
5.4 Conclusions

This chapter presents the findings of the case study performed on the requirements management process performed by the Rijksgebouwendienst in DBFMO projects. A case study is performed in order to assess the “qualitative” performance in relation to a defined conceptual model which is used as initial perspective for this assessment. By means of a short discussion of the empirical findings the additional insights for the knowledge-base on this process for the – relative – new context of DBFMO is assessed. A SWOT analysis is used to indicate the initial elements which the Rijksgebouwendienst must acknowledge or manage to safeguard the qualitative performance and development of this process. This is used as a basis to formulate strategies and plans to which are presented in the recommendations of this thesis.

One element which the researcher surprised is the relative lack of process structure or use of techniques during this process. For example, all of the respondents were asked to tell something about so-called requirements “trawling” techniques they used, or a methodology which was used to formulate the objectives, functional and/or performance specifications based on the information-input. The perception which was created on this was that a structural methodology in this process was still underdeveloped. It must be mentioned that the researcher doesn’t state that an good and qualitative requirements management process should always requires the use of an methodology or requirements “trawling” techniques – to identify and analysis the requirements of the stakeholders – but the current process exceeds in the unavailability of an structured process and unavailability of structured analysis and valuation techniques. It is perceived that the delegates and experts are not unwilling to develop such an approach or to standardize the process, but the capacity and incentives to develop such an method are lacking.
Next to the evaluation of the current requirements management practice it is the goal of this research project to evaluate the relevance of the application of the SE framework in this DBFMO-process of the Rijksgebouwendienst. Based on the knowledge gained by the case study and observations during the internship this chapter presents a discussion on the relevance of this framework. This chapter doesn’t provide a fully applicable SE methodology for the definition; procurement and management of DBFMO-project but – in line with the scope and delineation of this research project – it discusses the (1) relevance of this framework based on the insights of the current performance and context; and (2) provides an abstractive description of a normative model of application of the SE framework and relevant in this process. This provides an answer on the fourth and final research question for this research project:

*Research Question 4 =* Does the SE framework provide relevant elements which can be used to overcome the current weaknesses and shortcoming in the performance of the requirements management process of DBFMO-projects of the Rijksgebouwendienst?

Paragraph 6.1 starts with a discussion of the perceived relevance of the SE framework for the DBFMO-process by discussing recent experiences of SE in construction projects and by coupling the output of the case study with theoretical claims provided for SE. Paragraph 6.2 presents the description of a normative SE model for performance of the requirements management process in DBFMO-projects. This enables the identification and assessment of the relevance of normative SE elements. Paragraph 6.3 concludes this chapter by discussing elements which provide limitations or enablers for integration of SE in this phase in the definition of DBFMO-projects.

### 6.1 Relevance of Systems Engineering for Rijksgebouwendienst

#### 6.1.1 SE principles in project management of construction projects

The added value of SE for the design and management of construction projects is starting to recognize and more effort is performed to use SE principles in the project management of construction projects. However limited, more projects in the construction sector are performed by using principles derived from the SE framework. This use of SE in these projects is discussed in the work of Stichting Pioneering (2013) which is one of the institutions in the Netherlands that promotes the integration of SE in the project management paradigm of projects. Based on the application of SE principles in multiple housing projects they indicate that SE provides useful elements for the definition, design, realization and project management which positively influence the performance – time; money and quality – of these projects.
An example of such a project is the realization of a housing project in Almelo which was the claimed to be first housing project in the Netherlands which was realized by using SE elements (Stichting Pioneering, 2013). From the project is learned that the integration of SE principles in the design and realization process provides a positive contribution due to the increase of effectiveness of the construction procedures and management of the realization process for the project owner and contractor. More relevant for this work is the statement that the application of SE is perceived highly relevant for the performance of construction project with performance specification instead of traditional procurement. The work presents the findings of a research which assessed whether or not SE is useful in the formulation of a Design Specification that focusses on performance-specifications instead of traditional solution-oriented specification. They concluded that the concepts and tools related to SE provide a methodology which is capable in the formulation of a qualitative and structured Design Specification with performance-specifications of which the documentation is highly useable for the designing actor. Concluding it is framed that these practical experiences provide an initial acknowledgement or indication of the relevance of SE for the process of the Rijksgebouwendienst and the management of DBFMO projects.

SE provides a wide array of tools and techniques in order to effectively formulate the performance specification for a project with safeguarding their measurability, traceability and applicability. “SE should be integrated in the process at the start of the project definition.” (Stichting Pioneering, 2013).

“The structure and concept of SE forces the project to use performance-based briefing and formulate performance-specifications instead of using the traditional solution-oriented approach in briefing.”

(Stichting Pioneering, 2013)

6.1.2 Relevance of SE for DBFMO-projects and processes of the Rijksgebouwendienst

Reflecting the SE principles to DBFMO projects and processes of Rijksgebouwendienst

In addition to this initial indication of the general relevance of SE for construction sector and performance-based briefing, the assessment of the characteristics of a DBFMO-project provide an indication of the relevance and added value of the SE framework. From a project or system level it is observed that DBFMO-project are characterized by (1) increasing interoperable and interdependent systems; (2) emphasis on cost reduction with tight schedules and without quality reduction; (3) high number of systems and organisations involved; (4) combining multiple technical disciplines. In combination with the technical, social and managerial difficulties it is observed that the project and project-environment of a DBFMO-project can be defined as “complex”. The traditional project management paradigm is perceived to be inadequate for project delivery in complex environments as they assume a deep understanding of the project scope as well as the technology, stakeholders and risks involved (Locatelli, Mancini, & Romano, 2013). As this level of uncertainty and quality of information is observed for the DBFMO-project of the Rijksgebouwendienst, their performance and project management must yield competences to cope with this complexity. Multiple academic works acknowledge the

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93 Rombout appertments; Verhulstlaan in Almelo, the Netherlands.
94 According to the authors of the work.
95 Definition is done according to the background of the projects and guidelines defined by GAPPS (2007) and stated in the work of Locatelli et al. (2013).
capability of the SE framework to cope with this complexity which – in essence – require a shift from a “project perspective” to a “system perspective” (Checkland P., 1999; Locatelli, Mancini, & Romano, 2013; Janice & Mengel, 2008). SE provides the project management competencies to deal with this complexity as it enables this transformation by integrating traditional, technical and managerial disciplines in a holistic systems approach. This approach enables the management of complexity by integration of Systems Thinking which is required for projects in complex environments as the focus should not be on the sub-system, but on the whole system as is stated by Checkland (1999;2012): “What in the end justifies systems thinking is the fact that any whole has properties – the so-called emergent properties – that exist only in relation to the complete whole, as the whole is more than the sum of its parts.” Systems Thinking is able to provide competencies to contribute to the management of innovativeness, complexity and uncertainty by integration of flexibility in managerial activities (Kapsali, 2011). In addition, the Systems Thinking concept central in SE is indicated to be an ideal perspective to cope with complex problems involving incomplete data, unclear goals, human interaction and cultural/political/strategical consideration (Checkland P., 1999).

Combining these statements provide an argument for the use of SE in the practice of the Rijksgebouwendienst as it is perceived that this framework provides an adequate approach for successful realization of systems – in this case DBFMO projects – in complex environments. Central in SE is that it considers both the business and technical needs of the stakeholders influenced by the system and has the goal to realize a qualitative system which meets the user needs (Locatelli, Mancini, & Romano, 2013). The latter is achieved by means of the top-down design approach and the appropriate combination of techniques and tools – as Quality Function Deployment; Functional Analysis; Objective Analysis & Requirements Engineering – which can be traced back to the SE practice.

Reflecting SE principles on case study findings

The preceding chapter provided a wide array of information on the performance of the requirements management process in relation to the formulation of the OS document in DBFMO-projects. The question remains whether or not the SE framework is relevant for application in this process. The practical relevance of SE for the Rijksgebouwendienst is assessed by means of coupling theoretical and practical claims with the findings of the case study research. This coupling provided a more grounded indication of the level of relevance of SE for the Rijksgebouwendienst. The discussion per variable identified in the theoretical framework is presented in Appendix H. This discussion is summarized in table 5 which gives a presentation on how SE and related elements is claimed to overcome identified the shortcomings or weaknesses in the current requirements management practice of the Rijksgebouwendienst.
The practical experiences and theoretical reflection on the DBFMO practice by the Rijkgebouwendienst provide an initial perception on the relevance of the SE framework for application in the definition of the OS document by the Rijkgebouwendienst in DBFMO projects. The table indicates that SE provides a wide range of elements and/or tools which can contribute to the management of the shortcomings in the current process. In combination with the discussion on this reflection presented in Appendix, the general relevance of SE in complex and construction projects it is concluded that the SE can provide a positive contribution to the process of the Rijkgebouwendienst. A reflective note is that this analysis assumes the proper integration and performance of SE principles and elements but at this point this is regarded as an external factor. Practical experiences and theoretical discussions learned that SE is best used when integrated in the full life-cycle of a construction project. Therefore, as this research projects only focusses on the requirements management process in DBFMO-project, more research is required on its application in this process and in the full life-cycle of a project.

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**Table 5 - Claimed contribution of SE on identified shortcomings**

<table>
<thead>
<tr>
<th>Observation in case study</th>
<th>Claimed contribution SE framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commitment and Resistance of stakeholders</td>
<td>1) Incorporates stakeholder integration as core element.</td>
</tr>
<tr>
<td></td>
<td>2) Consideration and integration of “both the business and technical needs of stakeholders with the goal of providing a quality product that meets the user needs,”</td>
</tr>
<tr>
<td></td>
<td>3) System Engineers have the responsibility for the management and realization of systems and services which meet the needs of a sector or the influenced society.</td>
</tr>
<tr>
<td>Low level of requirements traceability or structural documentation of information input provided by the stakeholders in the process</td>
<td>4) Requirements Engineering is performed in order to capture, analyse and track system requirements.</td>
</tr>
<tr>
<td></td>
<td>5) Maintains requirements traceability as it constitutes the “ability to describe and follow the life of a requirements, in both a forwards and backwards direction.”</td>
</tr>
<tr>
<td></td>
<td>6) Goal is to constantly integrate and document the input of stakeholders in the process by means of documentation techniques.</td>
</tr>
<tr>
<td></td>
<td>7) Explicit nature decreases the distance of these stakeholders towards the substance of the process.</td>
</tr>
<tr>
<td></td>
<td>8) Structural documentation of design decisions and analysis-output decreases the loss of information as result of information-transfer during the life-cycle of a SE process.</td>
</tr>
<tr>
<td>Roles of Stakeholders</td>
<td>9) Requires a clear and known definition of roles in the process. It is the goal to identify the important stakeholders who are to be integrated in the process but safeguard the distance of them to the development of the system itself.</td>
</tr>
<tr>
<td></td>
<td>10) A project team/integrated Product Team (IPT) is a technique which guarantees the integration of different viewpoint in the process during the entire system lifecycle.</td>
</tr>
<tr>
<td></td>
<td>11) Goal to understand and integrate human, organizational, technology and behaviour concerns in the process of system-development. Creates need for a clear differentiation and management of roles and responsibilities of stakeholders.</td>
</tr>
<tr>
<td>Consideration of multiple perspectives</td>
<td>12) Life-cycle approach forces the project organisation to perform a Problem Definition and System Definition. By stakeholder and objective analysis an initial overview of the objectives and requirements of the stakeholders and their perspective on the problem.</td>
</tr>
<tr>
<td></td>
<td>13) SE contributes to the structural analysis of information input of stakeholders as it integrate a wide array of tools (Objective Analysis, Functional Analysis, Requirements Analysis) to structurally analyse the requirements of the stakeholders.</td>
</tr>
<tr>
<td></td>
<td>14) The goal is to design and realize a system which meets the requirements of the customer or clients in an effective and efficient way, the process must entail a proper requirements development or analysis process.</td>
</tr>
<tr>
<td>Methods used for collection of information &amp; Knowledge on formal procedures of process</td>
<td>15) Responsibility of the System Engineer to gain a clear perspective on the requirements of the stakeholders. The analysis tools provide basis for this understanding.</td>
</tr>
<tr>
<td></td>
<td>16) Incorporates a broad range of analysis tools which can be used for the collection and analysis (including verification &amp; validation) of information.</td>
</tr>
<tr>
<td></td>
<td>17) Continuous verification &amp; validation of information enables information-enrichment by feedback.</td>
</tr>
<tr>
<td></td>
<td>18) The SE process of requirements engineering must be performed in such a way that it acknowledges the different types of requirements, namely conscious, unconscious of undreamed.</td>
</tr>
<tr>
<td></td>
<td>19) Process is a highly structural performance and pre-determined activities which are to be performed in the process.</td>
</tr>
<tr>
<td></td>
<td>20) Provides an structural process or life-cycle for the top-down development of the system in which the logic dimension consists of three fundamental steps in which the structured framework of steps, phases and activities.</td>
</tr>
<tr>
<td></td>
<td>21) SE management plan is required for start of the process which indicates the required knowledge and steps to be performed.</td>
</tr>
</tbody>
</table>

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The practical experiences and theoretical reflection on the DBFMO practice by the Rijkgebouwendienst provide an initial perception on the relevance of the SE framework for application in the definition of the OS document by the Rijkgebouwendienst in DBFMO projects. The table indicates that SE provides a wide range of elements and/or tools which can contribute to the management of the shortcomings in the current process. In combination with the discussion on this reflection presented in Appendix, the general relevance of SE in complex and construction projects it is concluded that the SE can provide a positive contribution to the process of the Rijkgebouwendienst. A reflective note is that this analysis assumes the proper integration and performance of SE principles and elements but at this point this is regarded as an external factor. Practical experiences and theoretical discussions learned that SE is best used when integrated in the full life-cycle of a construction project. Therefore, as this research projects only focusses on the requirements management process in DBFMO-project, more research is required on its application in this process and in the full life-cycle of a project.
6.2 Normative SE model for requirements management process

Using the knowledge on the current requirements management practice in DBFMO-projects, this paragraph aims to present a discussion of the normative application of SE in the process of the Rijksgebouwendienst. The normative model is designed to give an initial impression how the process ought to be performed from an SE perspective. This model is based on the SE life-cycle phases identified in the theoretical framework of Chapter Four, namely the Problem Analysis & Requirements Analysis and the knowledge derived from the case-study and additional observations on the object of study. As SE provides a wide array of tools, methods and techniques which can be used according to the objective; goals and problems of the relevant process, the model is formulated by selecting the appropriate SE tools and techniques which are perceived relevant for the process.

6.2.1 Problem Analysis in SE process for Rijksgebouwendienst

Before the Requirements Analysis is performed, the first step in the process is the analysis of the problem and overall system at hand. Figure 24 gives an overview of the normative elements which can be relevant for the Rijksgebouwendienst in their practice. Due to the highly iterative character this overview doesn’t provide any linearity or order of performance of the identified activities. More important is the gained knowledge in this phase.

Figure 24 - Normative elements for Problem Analysis for Rijksgebouwendienst

A high number of works are available which discuss the theoretical and practical performance of an SE process. For this research project, the following sources are used as a basis for this normative model (Sage & Armstrong, 2000; BAM Infra, 2008; CROW, 2011; Locatelli, Mancini, & Romano, 2013; Department of Defense, 2001; Rijkswaterstaat & ProRail, 2009; INCOSE, 2010).

As is already acknowledged but perceived relevant to reply, this normative SE model only provide a abstractive description of how the researcher envisions SE to be performed in the context of the requirements management practice in DBFMO-projects of the Rijksgebouwendienst. Therefore, this model doesn’t provide any applicable elements but provide the first step in the integration of SE in these projects. More important is the identification of relevant SE elements and methodologies and the acknowledgement of the required information in the two SE phases.
It is observed that at the start of any DBFMO-project of the Rijksgebouwendienst the project organisation does not have complete information on the problem and solutions at hand. Therefore, the goal or objective of this initial phase is the formulation of the initial system and problem definition and to create insight in the needs, objectives, requirements and constraints towards this system. Central in this step is the Stakeholder analysis which provides valuable and important knowledge for the proceeding of the SE process. In addition, the System/context analysis should be performed to gain knowledge on the system in which the DBFMO-project is developed and which is used to identify external design constraints.

**Stakeholder analysis**

The formulation of the problem related to the system is subject to the perspectives, positions and powers of the stakeholders who influence the project. Therefore, at the start of a Problem Analysis the Systems Engineering of the Rijksgebouwendienst must create an overview of the relevant stakeholders and gain insight in their perceptions on the problem. These stakeholders can have different viewpoint about this definition of the problem and the scope of the future project and by means of analysis of these perspectives the problem definition is likely to match the stakeholder’s expectations. In addition, this analysis must be performed by the Rijksgebouwendienst to create insight on the initial objectives; requirements; goals; constraints and missions of the participants in the DBFMO process. A relevant factor which influences these requirements is the business processes and activities which are to be performed in the real estate object which is to be provided by the DBFMO-project. Therefore, the initial analysis of the objectives can be used by the Rijksgebouwendienst to identify the desired functions or performance which the system should perform on a top-level. As this gained knowledge is relevant for the definition of the system it should be also performed by the Rijksgebouwendienst to gain knowledge on the power, positions and interests of these stakeholders. The case study and observations during the internship learned that the current practice lacks the structural performance of this analysis and the effects of the social/political environments is mostly accepted as an external factor as this should be analysed at the outset of the process.

**Problem and system definition**

Based on the knowledge and output of the Stakeholder analysis the project organisation should be able to define an initial problem definition. This activity can be perceived as insignificant but its performance is crucial as “Writing code isn’t the problem, understanding the problem is the problem” (Curtis, Krasner & Iscoe, 1988). It is observed in the SE literature that the hardest part is identifying the problem correctly (Sage & Armstrong, 2000). Proper Problem Definition needs to occur at the start of any SE phase since “a problem resolution effort that is well-begun, in terms of being well-defined, is a problem half-solved.” By means of for example a situation assessment the Rijksgebouwendienst should create a clear perspective on how the stakeholders value and perceive the problem and system. In practice this means that the scope and delineation of the DBFMO-project is defined and discussed. Based on the stakeholder and context analysis, this should give an indication

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98 For more information on the use of Objective analysis or Objectives tree, please read Sage & Armstrong (2000) page 105.
of uncertainties and risks in the scope and delineation and the Key Performance Indicators (KPIs) which measure the overall success/quality of the system performance.

6.2.2 Requirements Analysis in SE process for Rijksgebouwendienst

Following the Problem Analysis is the performance of the Requirements Analysis phase. In most theoretical discussion on the performance of a SE process this is perceived to be the first and most crucial phase which relates to the System Definition of a SE object. Due to the complex and uncertain nature of the information the preceding Problem Analysis is performed to gain knowledge on the stakeholders and their perception towards the DBFMO-project. The Rijksgebouwendienst can perform this SE phase in order to define the stakeholder needs and objectives in context of the planned use; environment and identified system functions (Department of Defense, 2001). More specifically it can be stated that this phase is performed with the following objectives:

- To refine stakeholder objectives and requirements.
- To translate stakeholder objectives and requirements in top-level system objectives and requirements.
- To define functional objectives and top-level performance requirements for system
- To identify and define constraints (internal and external) that limited system development

These objectives indicate a close interrelation with the tasks performed and knowledge gained in the initial SE phase – the Problem Definition. This interrelation and verification of knowledge is one of the critical elements of SE which the Rijksgebouwendienst needs to acknowledge in this process. Figure 25 gives an overview of the process performance and the relevant SE elements which ought to be performed by the Rijksgebouwendienst and the project organisation in the requirements management process of DBFMO projects.

As stated, this description assumes linearity by discussing the phases and activities in a separate manner but in practice the highly iterative nature of the process means that the tasks – as for example stakeholder analysis and identification of objectives and needs of stakeholders – is a continuous process.
This process is performed to gain insight on WHAT the system must and to what quality level in order to meet the needs and requirements of the stakeholders and system environment (Department of Defense, 2001). When this is successfully performed the project team has gained insight on the scope of the system; top-level system functions and the related functional and performance requirements. In practice, this process is performed with constant iteration with the subsequent Functional Analysis – in which the system decomposition and functional requirements are translated in low-level performance requirements – in order to verify that the synthesised functions meet the stakeholder and system objectives (Sage & Armstrong, 2000).

**Objective analysis and Functional Analysis central in Requirements Analysis**

It is viewed that the Objective analysis is the most controversial and crucial step in the entire SE process (Sage & Armstrong, 2000; Department of Defense, 2001). The reason is that from this analysis very important products will be obtained which are used throughout the remainder of the definition stage and development of the system. In essence, the Objective analysis uses the input of the Problem Analysis provided by the Stakeholder analysis and defines the system objectives and functional requirements. Central in this analysis is the formulation of an Objective Tree in which the goals and objectives towards the system are decomposed on various hierarchical levels as is presented in figure 26.

The figure presents the hierarchical content of an Objective tree and the relation of this analysis to the output of the Stakeholder analysis performed in the first phase. Where the Stakeholder analysis is used to create an overview of the objectives and requirements of all relevant stakeholders towards the project, it is the goal in the Requirements Analysis phase to use this output in the formulation System objectives, System functions and functional requirements. Firstly, the Rijksgebouwendienst must define and decompose the objectives using the Objectives tree (Sage & Armstrong, 2000). Using the hierarchy concept of an Objective tree takes considerable thought by the Rijksgebouwendienst but using this will have enormous payoffs. As result of the limited objective analysis in the current practice, it is observed that the formulation of top-level goals and objectives is found to be extremely difficult in DBFMO-projects. However, the Rijksgebouwendienst must acknowledged the important

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101 Also referred to as the Value System Design by Sage & Armstrong (2000)
102 This must be acknowledged in the process of the Rijksgebouwendienst as the current practice lacks the structural performance of this analysis on the perspectives of the stakeholders which – from an SE perspective – significantly influences the performance of the process.
of definition of these objective because if they not choose the correct objectives for the system, it is unlikely that a “correct” system is developed (Sage & Armstrong, 2000; BAM Infra, 2008).

Using the output of the Stakeholder analysis will result in an Objective tree in which the top-level objective describes the goal and mission aspirations towards the real estate object of the DBFMO-project, while the lower-level objectives get more specific in how these goals are decomposed and are easier to measure. These lower-level goals are based on close interaction with all relevant stakeholders. It is the task of the System Engineer of the project organisation to use this process to enable the decomposition of the top-level objective. The output of this analysis must continuously be documented and verified with the stakeholders to make sure that the substance of the process meets the perspective of the stakeholders which safeguards the development of the system (Sage & Armstrong, 2000)

The formulation of these objectives and their decomposition in lower-level objectives will be an exhaustive process which requires allot of effort from delegates of the Rijksgebouwendienst and the relevant stakeholders who are placed in the project organisation. The value judgements in this process are often difficult to discuss but the positive notion is that the intensive discussion on the different perceptions on the objectives of the system means that it enables an early agreement on disputes in the process. However, the efforts will be not without any reason as the lower-level objective in the Objective tree will provide different purposes in the process and for the system development. At a first place these objectives provide the first indication of the Design Criteria, Performance Measurements or Key Performance Indicators for the DBFMO-project. The position of these performance measurements are presented in figure 27. These can be used to measure the success or failure in achieving the overall projects objectives. It can be expected that the lower-level objectives provide a more specific formulation of what is required from the system, for example the quality of the architecture or the importance of nuisance at workplaces. At this level in the objective tree it requires the System Engineer of the Rijksgebouwendienst – in corporation with the stakeholders – to make statements on when the success is perceived to be a success on this elements and what is expected that the system delivers.

For the definition of DBFMO-project the construction of an Objective tree has another benefit as the lower-levels of the tree often suggest functions which are required from the new real estate (Sage & Armstrong, 2000). As the analysis is based on input and with close interaction of the stakeholders, these functions represent the most important characteristics the DBFMO-project has to accomplish or suffice. This can relate to the providence of particular safety elements; the possibility to have different kind of workplaces; or to present specific artefacts of a military museum. As these functions are represented in the hierarchical decomposition of the objective analysis, they can be used in the interrelated Functional Analysis in which these top-level
functions are decomposed further until the needed understanding of the systems functions is obtained.\textsuperscript{104} The relation between the analyses is presented in figure 28.

![Figure 28 - Relation between Objective and Functional Analysis](image)

This Functional analysis is perceived relevant for the Rijksgebouwendienst in the definition of their DBFMO-projects as a proper functional description of the real estate project allows them to formulate the functional requirements independent of any solution-oriented specification (Sage & Armstrong, 2000). This approach safeguards the performance-based briefing in DBFMO-projects as it forces the Rijksgebouwendienst to specify the system from a functional-perspective – based on the current organisational process; needs and objectives for the project – and not to adopt a specific technical implementation approach at this early stage of the SE process. As for the Objective analysis the Functional Analysis is performed by means of the functional decomposition of the top-level functions. This analysis can be supported by process analysis tools as Functional Flow Diagrams, Structured Analysis or Data Flow Diagram to gain knowledge on the required functions of the system based on the current and desired business process. In the Stakeholder analysis this is already mentioned as a thorough analysis of the required process in the future real estate object will provide functional requirements at this stage of the definition project which are to be integrated in the system definition (Sage & Armstrong, 2000).

By using the output of the Objective and Functional analysis the Rijksgebouwendienst can define an initial system definition and/or decomposition for the DBFMO projects. This is achieved by the coupling of the output of the two analyses. In essence does the functional decomposition provide the required functions and subfunctions for the real estate object and the objective analysis provide initial performance measurements or quality measures which the system needs to provide. As the functional decompositions is directly based on the objective analysis, the performance measurements can also be coupled to these defined functions. This relation of the three concepts is presented in figure 29.

\textsuperscript{104} It is observed in the current practice of the latest DBFMO project that the business process and activities of end-users are analysis but the teams indicated that these analysis could not be used in a structural manner in the current OS-document. This SE model provides a structural manner as it firstly identifies the top-level functions which the system has to provide followed by a further analysis and decomposition in the Functional Analysis which is based on the current or desired business process of the end-users.
Requirements Analysis and Allocation

Following the Objectives and Functional analysis which results in an initial System decomposition, is the allocation of system requirements in the Requirements Analysis or Requirements Allocation. The formulation of requirements for the system elements are the product of all of these initial definition efforts that will lead to and structure the further development of the system (Sage & Armstrong, 2000). This is acknowledged in the work of CROW (2011) who identified the requirements as the link or bridge between the user/stakeholder needs and the delivery of the system. It is important to acknowledge that requirements are referred to by SE practitioners as the “broad, top-level statements that describe the purpose and functioning of a system and its major components in support of client or enterprise needs and objective.” The goal of this activity is to bring together all of the information generated during the System Definition into summarized statements that helps to define the system. In this step all of the identified needs, objectives, criteria’s and constraints that will be incorporated into the “system” must be allocated to the System decomposition. Therefore, this activity is used to provide information about what major functions the system has to deliver; how this accomplishes its objectives; how user needs are satisfied; and to what quality the system has to provide for the users; consumers and environment.

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105 One of the highly respected institutions which exploits its expertise on performance based specification and Systems Engineering in the Netherlands.

106 Requirements or system specification are relatively different as to technical specification of which the latter also are referred to as performance specifications in the DBFMO context of het Rijksgebouwendienst.
Different techniques are available to identify what the stakeholders – including the Rijksgebouwendienst – really want or need from the system. This process is perceived to be very difficult and it is acknowledged in the academic literature on this activity in an SE process that it is important that sufficient effort is focused on this identification. As this is already broadly discussed in the preceding sections and in the literature this topic of Requirements Engineering will not be further discussed. More important is on the performance and scope of this activity. The objective of this step should be “the development of a good set of top-level system requirements to guide (...) the further development and deployment of the system.” (Sage & Armstrong, 2000) The requirements which are to be identified are translated into system specifications which are the functional statements that the DBFMO-project must satisfy.

For the development of these requirements the reader must be aware of the fact that this is highly dependent on the substance of the process and project and therefore at this point no detailed normative performance is presented. As this step is the most crucial step in the definition process, it is also perceived to integrate the highest subjective character (CROW, 2011). At this point, the System Engineer performs the requirements identification with a top-down approach and bases the formulation of the system requirements on preceding efforts of the process. In essence this top-down approach can be characterized by the following steps:

Figure 30 indicates that this step will result in the verified allocation of requirements to the system and identified system decomposition. In essence this means that this activity must result in the coupling of the System decomposition with the identified top-level system requirements. This requires the allocation of requirements to the functions and subsystem defined in the preceding analyses. This output is perceived to be the significant output of this SE phase – the System Definition – and will be further refined in the System Development phase.

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107 For more information, please read for example (Sage & Armstrong, 2000; Arayici, Ahmed, & Aouad, 2006; Bahill & Henderson, 2004; Cant, McCarthy, & Stanley, 2006)
Output of Problem Definition and Requirements Analysis phase

By means of the description Problem Definition and Requirements Analysis phase the normative model has indicated process which ought to be performed in the requirements management process from an SE perspective. The output of this initial phase – System Definition – of a SE process provides a initial definition of what the system must produce or what functions and quality is required from the real estate object which is to be developed (Department of Defense, 2001; Sage & Armstrong, 2000). The functional requirements, as with the objectives, provide the primary source of requirements which are integrated in the top-level system decomposition. Combining these functional decomposition with the allocation of the requirements provide an initial description of the system requirements which provide the basis for the formulation of the performance specification in the next phase – the Functional Analysis. This subsequent phase closely relate to the process of formulation of the performance-requirement for the OS document by the experts of the Rijksgebouwendienst. This relation of the two phases is acknowledged by Sage & Armstrong (2000) as: “Although the System Engineer is responsible for the system specifications, which are prepared near the end of the System Definition phase, there are second-level implementation specification that will be developed later in the process by experts in appropriate engineering disciplines such as mechanical, architectural, safety or electrical. The Systems Engineer will often be involved in technical direction and integration efforts to ensure that further refinement of performance specification comply with the system level specification (Sage & Armstrong, 2000)."
6.3 Integration of SE in current context

At this point, it is important to acknowledge the observed enablers and limitations in the current context of this process which influence a possible integration. These elements will be shortly addressed in this paragraph based on knowledge derived during the internship in the Rijksgebouwendienst and by the performed case study in combination with the results of the SWOT-analysis. The elements are categorised in the factors related to Environment, Organisation and Technology.

6.3.1 Enabling elements for integration SE in practice Rijksgebouwendienst

The identified elements which can positively influence the implementation of the SE framework in the current practice of the Rijksgebouwendienst are presented in table 6.

| Environment |
| 1) Stakeholders require more feedback and identification with substance of the process |
| 2) Use of SE available within other Dutch governmental organisations (RWS) |
| Organisation |
| 3) Broad knowledge-base and experience on requirements management process and performance of definition phase |
| 4) Knowledge; acceptance and enthusiasm towards theoretical foundation and application of SE available – however dispersed – in the organisation |
| 5) Project group already established for development of SE within organisation. |
| 6) Young professionals with limited experience in traditional procurement and with adequate knowledge-level for acceptance; use and development of SE principles. |
| Technology |
| 7) Availability of IT system solutions for documentation management to safeguard requirements traceability. |
| 8) Functional analysis on business process of end-users performed in latest DBFMO-project to identify required functions and functional requirements. |

6.3.2 Limitations for integration SE in practice Rijksgebouwendienst

The identified elements which can negatively influence the implementation of the SE framework in the current practice of the Rijksgebouwendienst are presented in table 7.

| Environment |
| 9) Hierarchical and political context: |
| - Negatively influences the completeness and certainty of the information. |
| - Create a very sluggish decision making process. |
| 10) Use performance-based briefing not fully accepted due to limited knowledge and traditional mindset. |
| 11) Public stakeholders not always have an adequate sense of urgency to cooperate in an early stage of the requirements management process. |
| 12) High level of resistance on decision to use DBFMO in projects as stakeholders have the fear to lose control on the process. |
| 13) Stakeholders want leading role in the definition process as they have the fear to be left out of the process. |
| Organisation |
| 14) Limited availability of capacities to perform effective requirements documentation to formulate central DBFMO-project document and increase requirements traceability. |
| 15) Requires significant investment of resources to develop applicable SE format to performance-based briefing of real estate objects in DBFMO-projects. |
| 16) Use performance-based briefing not fully accepted due to limited knowledge and traditional mindset. |
| 17) Positive contribution of extensive analysis of objectives and requirements of not fully recognized. |
| 18) Definition of roles in DBFMO project organisation and OS-team is not structured and varies over the projects. |
| 19) Current structure of the DBFMO life cycle requires the completion (80%) of the OS when used in dialogue phase. |
| Technology |
| 20) Limited availability of IT systems to perform effective requirements documentation to formulate central DBFMO-project document and increase requirements traceability. |
6.4 Conclusions

As the added value of SE for design and management of construction projects is starting to be recognized, more applications of the framework are observed. The goal of this chapter was to provide an assessment on the relevance of the implementation of this framework in the current requirements management practice of the Rijksgebouwendienst. Firstly, the reflection of the SE principles on the context of DBFMO projects indicated that the use of SE with the Systems Thinking concept enables the transformation from a traditional project governance to a system governance. As the DBFMO-projects are categorized as complex the traditional project management paradigm is perceived to be inadequate for project delivery of these projects. The chapter indicated that it is claimed – by theoretical works and practitioners – that SE provides the competencies and methods to deal with this complexity and therefore is ideal to manage projects involving incomplete data, unclear goals, human interaction and cultural/political/strategic considerations.

As this relevance of SE for the DBFMO-projects is assessed on a abstractive-level, the practical relevance of SE for the Rijksgebouwendienst is assessed by means of coupling theoretical and practical claims with the findings of the case study. The latter relate to the weaknesses and shortcomings of the current requirements management practice and by reflecting these on the SE principles it is concluded that this framework provide a wide array of elements which form a positive contribution for the current process in the definition of DBFMO-projects. In particular it is indicated that SE is founded on the structural analysis and documentation of the stakeholder information and input which leads to a transparent and open process. The latter was perceived to be one of the significant shortcomings of the current practice which evokes a significant amount of resistance and dissatisfaction with stakeholders in the process.

Another significant contribution of SE when used in the management of complex project is the structural and highly iterative process approach. As the current process lacks a clear structure and its performance is highly dependent on the responsible project managers, the chapter indicated that the performance of a SE process is highly structured and with close interaction with the stakeholders. This structured performance of a SE oriented requirements management process – in combination with the discussion of relevant SE elements for the Rijksgebouwendienst - is indicated in the discussion of the normative SE model for the Rijksgebouwendienst. It is indicated that the SE framework provides significant elements which can be used to provide the definition of the real estate object by means of the System Thinking and functional requirements. By performance of a proper Problem Definition and Requirements Analysis phase the project organisation will gain insight on what the system must deliver and what quality levels are related to the top-level system functions. This normative model doesn’t provide an applicable framework as this requires the further conceptualization and definition of the elements, but the process is displayed as are the positive contribution towards the requirements management process. Therefore, it can be concluded that SE is not only perceived relevant but it its implementation can provide beneficial elements for the top-level definition of the real estate object which is used as a basis for the further definition of the OS document.
Part III

Conclusions
7. Conclusions and Recommendations

In this chapter we consider the work performed and draw conclusions from this research. Paragraph 7.1 provides a confined overview of the research performed, and in paragraph 7.2 the research questions are addressed. This latter paragraph also provides an selection of the research results provided in this thesis. However, the goal of this section is not just to summarize and restating the substance of the preceding sections and analysis, but also to provide an assessment on the significance of the findings in this work and to provide an understanding in a broader context or how the outcome can apply to a larger concept. Therefore, following the first two paragraphs is a discussion on the theoretical and practical relevance and contribution of this research and findings in paragraph 7.3. Paragraph 7.4 presents an outline of the theoretical and practical recommendations derived from this research. To provide a critical reflection on the research and the presented outcome, paragraph 7.5 discusses the validity of the research. The chapter is finished with a discussion on the limitations of the research and the findings.

7.1 Research overview

This thesis started with the observation that the requirements management process in construction projects is not performed according to desired standards and still contains a wide array of limitations. It became clear in the literature study that this process – performed at the start of a construction project to create insight in the stakeholders and system requirements and constraints – has only been limited the subject of research performed in the context of PPP or integrated works projects. These claims are acknowledged in the practice of the Rijksgeboouwendienst which performs this process to create a clear understanding of the requirements; goals and objectives of their public clients towards the real estate object which is to be realized. As this process is perceived to be a critical element for the successful delivery of construction projects, the Rijksgeboouwendienst indicated that their current practice in their DBFMO-projects lacked a structural and adequate understanding of the performance of this specific process performed in the early stages of system definition. To overcome these limitations – observed in theoretical and practical contexts – multiple initiatives have preceded to assess this process but a practical and applicable framework is needed to improve the current performance as the traditional project management paradigm is perceived to be unable to cope with the complexity of DBFMO-projects and its environment. A framework which is perceived to have potential added value for the qualitative performance of the requirements management process and formulation of performance-based briefing is the Systems Engineering framework.

The objective of this research projects was two-fold as it aim to create insight in the current performance of the requirements management process in the context of DBFMO-projects and to evaluate the relevance of SE and SE elements for integration of the current practice of the Rijksgeboouwendienst. The question that we
addressed to contribute to this objective is: “How can the current performance of the requirements management process of DBFMO-projects by the Rijksgebouwendienst be improved by the integration of the Systems Engineering framework?” To answer this question the research project was divided in two sections in which the first aimed to assess the performance of the current practice by means of a case study research. For the performance of this exploratory case study on multiple DBFMO-projects from the portfolio of the Rijksgebouwendienst a conceptual model is formulated which is used to identify six variables which are perceived relevant in the performance of the requirements management process. By formulation of propositions the research used the pattern matching approach to assess how these were relevance; safeguarded or differently managed in the DBFMO context and how this influenced the overall performance of this process.

Using the knowledge derived from the case study and observation during the internship of the researcher, the next section in this research project addressed the relevance of the SE framework for integration in this process of the Rijksgebouwendienst. As this framework proposes an full life-cycle approach and therefore it can be expected that this framework should provide tools for the whole DBFMO-process performed by the Rijksgebouwendienst, this research coupled the substance of the requirements management process with relevant elements of the framework. This knowledge is used to assess the relevance of the framework and its elements, and how this can be translated in an initial normative SE model for the requirements management process of the Rijksgebouwendienst.

7.2 Addressing the research questions

7.2.1 Context of requirements management process

The Rijksgebouwendienst is commissioned with the management of the housing for the Dutch government. For the proper performance of their projects multiple tasks are transposed to one of the four directorates. As the requirements management process is perceived to be a crucial element in the performance of construction projects, the responsibility for its performance is segregated between two directorates (Vastgoed & Projecten) which each have their own perspective on their contribution; relation and performance. Despite this difference in perspective this research primarily focussed on the process performed in the responsibility of the latter directors as this directive is responsible for the performance of the projects after these are – currently – initiated by the Directorate Real Estate. Central in the definition phase which leads up to the formulation of the OS document, is the performance of the requirements management process. In this process the delegates of the Rijksgebouwendienst interact with different public stakeholders – dependent on the project and position/interests/powers of the participating public parties – to create insight in the current situation and their requirements towards the new – or renovated – real estate object.

Based on an analysis of the researcher some insights are provided in Chapter3 on the performance of this initial process. However, the level of documentation and descriptions on the performance of this specific process were limited and scarce and this is perceived to be a significant finding for the research. The context of the performance of this process could be defined and its influence – stakeholder integration; hierarchical structure;
role of OS model; and influence of concept of performance-based briefing – on the process are assessed in the case study if necessary and relevant. More important was that at this point no clear structure or approach for the requirements management process could be provided and the quality system of the Directie Projecten lacks a formalization of this process. Therefore, it is questioned whether the use of the Nordic-Five level structure and the concept of performance-based briefing in the OS document is safeguarded in the process performed in DBFMO-projects as a significant degree of freedom is perceived.

7.2.2 Theoretical framework for assessment process and normative SE model

By identifying relevant theories on requirements management and SE, the theoretical framework presented in Chapter Four aimed to serve as a bridge between the theoretical and empirical elements in this framework. This is developed with the purposes to provide a theoretical perspective to assess the current performance of the specific DBFMO-process and to identify the elements – or delineation – of the SE framework which can be related to this process performed in the definition of DBFMO-projects.

Framework for assessment qualitative performance of requirements management process

By means of an extensive literature study six variables are identified. These variables are derived from – primarily – literature on the performance of the process in the context of traditional procurement projects and are discussed and evaluated in semi-unstructured interviews with perceived relevant delegates in the Rijksgebouwendienst. Based on this research it was concluded that the variables Experience of team with process; Commitment and Resistance of Stakeholders; Roles of Stakeholders; Consideration of multiple perspectives; Methods used for collection of information; and Knowledge on formal procedures of process are perceived relevant for the case and used for the assessment of the qualitative performance of the object of study. This variables are perceived to have a significant influence on the performance of a requirements management process and therefore should be managed properly – or acknowledged – by the responsible stakeholder. By means of a conceptual model the researcher formulate theoretical propositions for each of these variables. These propositions are used to examine their relevance and application in the processes of the selected DBFMO-projects and this enabled the evaluation of this process. Despite the fact that the variables are derived from an extensive literature study and semi-unstructured interviews, it is acknowledged at this point that their formulation obtain an high level of subjective interpretation by the researcher.

Framework for formulation normative SE model

The presented literature study on the SE framework Chapter Four discussed the practical applications of this project management paradigm in construction projects. By comparing the requirements management process with an SE life-cycle it is concluded that they are seemingly alike. Insight in the definition process for DBFMO-projects learned that this consists of multiple stage which can be related to the Problem Definition, Requirements Analysis and Functional Analysis in a SE process. As the Functional Analysis is observed to be the process in which the specific performance-specification on a component level are formulate by experts, this process is left out of the selection as the delineation of this process is confined to the process which is performed in order to indicate and formulate the high-level objectives; goals; requirements and functionalities.
7. Conclusions and Recommendations

towards the real estate object subject in the DBFMO project. This results in the integration of the life-cycles on Problem Definition and Requirements Analysis to be assessed in the formulation of the normative SE model for the object of study.

7.2.3 Evaluation of performance requirements management process in DBFMO-projects

The case study proved a diffuse set of insights on the requirements management process in DBFMO-projects. By means of interviews conducted with delegates in the project organization of the projects, the case study created insight in the practical performance but also in the theoretical relevance of the propositions and variables for this project.

Theoretical relevance of case study research

By means of the empirical findings of the case study it is concluded that all of the propositions and variables are relevant for the requirements management process in the context of DBFMO-projects. However, a significant notion is that the definition of the variables are for all instances limited and by means of the research on projects of the Rijksgebouwendienst, the research enables a further definition of their relation towards the qualitative performance of the process. By means of this conceptualization the limited knowledge on the performance of the requirements management process in the context of DBFMO-projects is further enriched.

The case study learned that the level of experience of the team highly influences the performance of the requirements management process as the mindset derived from earlier experience – DBFMO or traditional procurement projects – determines the approach used in the DBFMO-projects. The theoretical perspective is enriched as factors on level of acceptation of DBFMO-concept; knowledge on required processes in requirements management process; and knowledge on substance of performance-based briefing concept are identified to be related to the variable. On the other side, the level of experience of end-users\textsuperscript{108} is a factor which influence the performance of the process as it relates to their ability to perform their provided responsibility; provide collective information instead from an individual perspective; and to participate actively in the process. As this provides theoretical knowledge, it is integrated in the SWOT-framework to be acknowledged by the Rijksgebouwendienst in the formulation of the project organization for the DBFMO-project.

Another finding is on the acknowledgement of the importance of the commitment of stakeholders towards the process. The case study confirmed that a lack of commitment of the stakeholders influences the progress of the decision-making process as their limited participation in the process decreased the quality of information in the requirements management process. By identifying the need and significance for the Rijksgebouwendienst to create a ‘sense of urgency’ for stakeholder to actively participate in the progress, the research identified the effects of a lack of commitment which wasn’t already discussed. In addition, the research identified multiple potential factors which influence the performance of the process as they are found to be potential sources of resistance of stakeholders. These sources are the hierarchical decision to use DBFMO; the lack of knowledge of

\textsuperscript{108} Or other stakeholders apart from the professionals of the Rijksgebouwendienst
stakeholders with DBFMO and concept of performance-based briefing; the limited identification with substance of the process; the fear to be left out of the process or to have no control on its progress. As some of these factors cannot be directly managed by means of the Rijksgebouwendienst, one important factor which they must acknowledge is the importance of requirements traceability during the process. This factor influences the limited identification with the substance of the stakeholders with the process and is frequently identified to influence the qualitative performance of the requirements management process. This relates to the structural documentation of information-input of the stakeholders during the process and to the argumentation to the output of the requirements management process.

Finally, a finding of the research project which is perceived significant to be discussed in this section is the importance of a consequent stakeholder management in the process as different factors are identified on this element that influence the performance of the process. As the theoretical knowledge discussed that a clear definition of roles to the stakeholders safeguards the performance of the process, the research project provided an enrichment of the knowledge-base as it identified four factors in relation to stakeholder management which influence this performance. These factors are (1) level of structural and considered definition of roles and responsibilities of stakeholders; (2) level of acceptation of role and defined boundaries of responsibilities; (3) level of consequent performance of role by professionals of Rijksgebouwendienst; and (4) level of mandate of delegates in the process. In addition to these factors it is observed that the professional in the process – in this case the Rijksgebouwendienst – must safeguard the core values and interests of the stakeholders but also safeguard the performance of the process. In this project it is observed that the Rijksgebouwendienst found it difficult to balance between ‘satisfying the client’ and ‘safeguarding the performance of the process’ and this influenced the performance of the process as – for example – end-users are provided roles which they were not able to fully perform.

**Practical relevance of case study for Rijksgebouwendienst**

As the case study enabled the enrichment of the theoretical findings, it directly provided practical insight on the qualitative performance of the requirements management process by the Rijksgebouwendienst. Strengths, weaknesses, opportunities and threats are identified as factors which influence the practical performance of the process by the Rijksgebouwendienst. This provides the practical relevance of the evaluation of the requirements management process as the output of the case study is used to identify elements which the Rijksgebouwendienst can use; must acknowledge or manage in order to safeguard the qualitative integration; translation and documentation of stakeholder requirements in the OS document in their current and future practice.

The research indicates that the portfolio of the Rijksgebouwendienst provides a rich set of projects – DBFMO and non-DBFMO projects – which can be used to evaluate requirements engineering techniques and experiences and knowledge derived from these projects can be used to define the practice in DBFMO projects. On the other side, weaknesses in the current organizational context of the Rijksgebouwendienst in relation to this process relate to lack of formal and applicable process description, quality objectives or guidelines for
process; limited acceptation of performance-based briefing and DBFMO projects; and sluggish decision-making process due to hierarchical structure and political context. More practical on the performance of the process it is found that the weaknesses relate to the lack of a structural and consequent stakeholder management; limited analysis of information-input, performance of thorough objective-analysis and the prioritization of objectives/requirements; and the limited capability of IT systems and capacities of employees of Rijksgebouwendienst to safeguard requirements traceability in the process.

On the overall performance of the requirements management practice the research did not provided any statements. As the case study research provided a wide array of findings on the variables and identified their relation on the performance and outcome of this process, no statements on performance is provided by the lack of a best-practice. In addition, the quality of the outcome of the process is derived by the assessment of the user satisfaction with the real estate and at this point this is not integrated in the scope of the research. Therefore, the research only provided statements per variable and their relation towards a qualitative performance of the requirements management process.

7.2.4 Relevance of SE for practice Rijksgebouwendienst

Using the output of the case study on the variables and formulated SWOT elements, the research project aimed to provide an assessment on the level of relevance of the SE framework for integration in the object of study. By combining practical experiences on the added value of SE in the definition, procurement and management of construction projects with the coupling of SE elements from the Problem Definition and Requirements Analysis phases it is concluded that SE can provide a positive contribution for the process of the Rijksgebouwendienst. By discussion of a normative SE model for the requirements management process – with the goal to formulate the top-level system requirements based on the stakeholders input – the relevant SE elements are integrated in a process model which can be used for the definition of the DBFMO real estate object. This normative model consists of the allocation of multiple activities and analysis – Situation assessment; Stakeholder analysis; Problem definition; Objective analysis; Functional analysis; System decomposition; and Requirements analysis – which together are perceived to be performed to provide the input for the formulation of the performance specification in the OS document. Despite the fact that this normative model only provided an indication on how the process could be performed from an SE perspective, it provides significant insights for the Rijksgebouwendienst how this can help them in formalizing the process. In addition, theoretical claims from the SE perspective are coupled to the weaknesses and threats identified for the current requirements management practice and this indicate a highly positive added value of the integration of SE in the practice of the Rijksgebouwendienst.

7.3 Research contribution

The main contribution of this research project is that insight is provided in the performance of the requirements management process in the context of DBFMO-projects and that it is indicated how the integration of the SE framework in the project management paradigm of the Rijksgebouwendienst can overcome/management shortcomings and weaknesses identified for this process. Before this research descriptions
and definition on variables influencing the performance of the requirements management process were available, however they were perceived to be derived from studies performed in the context of traditional procurement projects. By reflecting this knowledge on the performance of the process performed by the Rijksgebouwendienst, the research not only provides valuable insight for the Rijksgebouwendienst on their performance of this process, but it also provide relevant knowledge and insights on the identified variables in the context of a DBFMO-project. This provides an initial scientific relevance as this knowledge was before the start of this project only limitedly available.

Aside from this knowledge, the formulation and discussion of the normative SE model provides valuable insights for delegates of the Rijksgebouwendienst who already have a positive perception towards the integration of this framework. It is observed during the internship that the perspective on the use of SE in the project management of the Rijksgebouwendienst differentiates from very positive to very negative. On what assumptions these two perspective are based is not relevant at this point, but what is that the assessment of the relevance and normative application of SE provide arguments for the initiation of further research on this framework.

### 7.4 Recommendations from research project

The research project provided a wide array of interesting findings which can be viewed from a practical and theoretical perspective. At first place, the performed case study and SWOT-analysis are used as a basis to provide practical recommendations which the Rijksgebouwendienst can use to safeguard and positively develop their current requirements management practice. These recommendations are categorized in table 7 in *Environment, Organisation and Technology*.

<table>
<thead>
<tr>
<th>Environment</th>
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<tbody>
<tr>
<td>1) Stress the importance and influence of structural definition of roles and responsibilities in requirements management process.</td>
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<tr>
<td>2) Increase knowledge of public clients by education in DBFMO-projects to cope with influence of resistance of stakeholders</td>
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<tr>
<td>3) Stress the importance and positive influence of mandate of delegates in OS team in the requirements management process.</td>
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<tr>
<td>4) Enable the structural integration of analysis of business process of end-users for the formulation of top-level system requirements.</td>
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<td>5) Create sense of urgency with public clients to actively cooperate in the early stages of the requirements management process.</td>
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<th>Organisation</th>
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<tr>
<td>6) Structurally evaluate contribution of DBFMO project and incorporate findings in education for public clients.</td>
</tr>
<tr>
<td>7) Evaluate/manage level of acceptance and knowledge on DBFMO and performance-based briefing concepts in project organisations.</td>
</tr>
<tr>
<td>8) Structurally evaluate requirements management process to enable formulation of “best-practices” and quality management system.</td>
</tr>
<tr>
<td>9) Acknowledge importance of position of Rijksgebouwendienst in requirements management process and formulation of OS.</td>
</tr>
<tr>
<td>10) Improve documentation requirements management process by investments in use of documentation techniques in Windows Office.</td>
</tr>
<tr>
<td>11) Invest in development/research of integration of SE in project management paradigm for project portfolio.</td>
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<tr>
<td>12) Apply an standardized definition of stakeholder management and definition of roles in projects.</td>
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<th>Technology</th>
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<tr>
<td>13) Manage that the structure of the digital OS model in Relatics is the result of the requirements from the requirements management process and performance of DBFMO-project and not vice versa.</td>
</tr>
<tr>
<td>14) Make sure that IT systems enable the structural documentation of the output of the requirements management process.</td>
</tr>
</tbody>
</table>

Our main recommendation with regard towards future research is to further research the application of SE in the management of the requirements management process, but also to extend this towards the full life-cycle of an DBFMO-project. Due to the time-constraints this research only evaluated the relevance of SE for the
process in the definition phase of a DBFMO project. On the first recommendation, it is acknowledged that this research did not provide a fully applicable SE model but only assessed its relevance which resulted in a normative model. The next step in its integration is to further expand this normative model and invest resources for further application in the process. It can be envisioned that an experiment is designed in which the SE element are applied in the context of a DBFMO-project, thereby creating insights on the pros and cons of this normative model.

In addition to this research proposition which focuses on the practical assessment of the normative SE mode, it is perceived to be relevant to perform an research with the goal to formulate a normative SE model for the whole DBFMO life-cycle. Due to the life-cycle approach SE is best used when the whole process is managed by using SE principles and therefore the scope of this research should be expanded towards the whole DBFMO-process. This can provide valuable insight how DBFMO-projects can benefit from the framework as projects in for example the infrastructure sector already have acknowledged.

Finally, it is perceived that the process performance of requirements management process requires further research on elements on stakeholder management for example. More insight is required to define a “best-practice” for the stakeholder positioning and performance in the requirements management as it is observed that the stakeholders performance highly influence the qualitative performance of this process.

7.5 Research validity

The quality of an empirical research project as presented in this thesis is assessed through establishing its validity. In essence, validity of a research and its findings are perceived to be the level in which these correspond accurately to the real world. The validity of a research can be discussed by a large number of different concepts as for example the construct validity, internal validity, reliability, or criterion validity. However, for the scope of this research projects it is perceived that it is sufficient to address the general level of validity – in combination with the described limitations of the research – of the research and what techniques are used to increase the validity of the findings presented in the previous sections.

Firstly it is acknowledged that the variables and propositions defined for the assessment of the process are formulated by the perspective of the researcher. Since the academic knowledge on this research – and in particular in the context of PPP and DBFMO projects – is scattered and limited, the researcher was forced to combine literature in order to define the six variables. This is also the reason that the variables are used as initial perspective and not provide limitation on the freedom of assessment of the empirical data. This is a means which increases the validity of the findings as it enables the research to integrate findings which were not defined in the initial theoretical framework for the projects.

Aside from this limitation provided by the scope of the case study, the output of this analysis on the process can only be used for limited generalization. The case study is performed by means of interviews these provide the primary data collection. It is acknowledged that the interviews integrate biased and subjective views of the respondents and therefore the risk of equivocal evidence or biased findings being allowed to influence the
output of the analysis is considered to be high. To increase the validity of the empirical findings, the output from the cross-case analysis of the cases is reflected upon by interviews of outlying DBFMO projects. As this increases the validity of the findings over the DBFMO portfolio of the Rijksgebouwendienst, it does not provide any means for the generalization of the findings on the project portfolio of the Rijksgebouwendienst. Generalization is perceived as one of the significant and most common criticisms on a case study research which is highly dependent on interviews as a data collection method (Leiringer, 2003). This means that the output of the case study can only be perceived in the context in which it is performed and can only limited be extracted on other projects. In retrospect, despite the limited generalization of the findings they can be used to identify strengths and weaknesses of the performance of the process in these projects which can be used by the Rijksgebouwendienst in the further performance of this process.

A side of these two elements on the validity of the research this can also be assessed by means of its reliability. The reliability of the study is determined whether or not it is possible to repeat this and find the same results. It is expected that thesis integrates different elements which increases the reliability of this work. Firstly, a thorough description of the research method and the case study logic & design is formulated in Chapter 2. This research method defines the data collection method used in the case study and describes the interview protocol used. All these interviews are recorded and subsequently transcribed. These recordings and transcriptions are stored in a database which can be accessed if this is desired by the reader.

### 7.6 Limitations of case study and findings

The first limitation is identified in the selected perspective which is used to analyse the object of study. Chapter Three described the perspective used for the assessment of the process in DBFMO projects. The scope of this theoretical framework has primarily been confined to the requirements management process performed in the definition phase of DBFMO projects. Accordingly, since there are many issues relating to the performance of this process which are not been addressed it is expected that the findings do not provide a full perspective on the elements which determine the success of the performance of this process and thereby the formulation of the OS document. For example, it is acknowledged that the case study mainly focusses on the process performed which is performed to enable the formulation of the substance OS document. This delineation is selected due to the limited experience and knowledge of the researcher on the concept of performance-based briefing and the limited time available for the performance of this research project. As a result, the research focusses on the configuration of the requirements management process which results in the formulation of the OS document, and no statements are made on how the performance-based briefing concept should optimally be formulated in the OS of DBFMO construction projects. In retrospect, the knowledge derived from the process and substance of DBFMO project is used to assess the relevance of the application of the SE framework in the context of the current performance-based briefing practice.

In relation to the subjective and biased view of the respondents it is acknowledged that the empirical findings are highly influenced by the constant interaction between the professionals which are interviewed. This limitation is perceived to relate to the concept of “Groupthink” which is defined as a “mode of thinking that
people engage in when they are deeply involved in a cohesive in-group, when members’ strivings for unanimity override their motivation to realistically appraise alternative courses of action.” (Janis, 1972). This concept is perceived to highly influence the objectivity of the respondents as this is influenced by the cohesion of the group of professionals which strive on the illusion of invulnerability and the fact that they all agree. As a result, the objectivity of professionals can be decreased and an “common opinion” is found which is displayed in the output of the research. Despite the fact that the concept of Groupthink is acknowledged at this point, no clear consequences can be related to the output of the analysis.

A third limitation of the empirical findings is found in the qualitative nature of the research study performed. This research only integrates a qualitative study which is used to assess, discuss and enrich the predicted substance and relation of the variables on the performance of the process in the context of PPP and DBFMO projects. No quantitative study could have been performed create more insight in the causality of these variables on the performance of the process and the significance or hierarchy of these relations. It can be imagined that the performance of a quantitative study on these variables and their relation to the dependent variables can be used to enrich these findings. However, as a result of the time constraint this quantitative assessment of the relations is left out of the delineation of the research methodology. As a result, the analysis of the process is only based on the descriptive nature of the qualitative findings of the interviews.


Bibliography


