

MASTER THESIS



Assessing the Quality of the Requirements Process

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MASTER THESIS MAREIJE JOCHEMSEN

Assessing the Quality of the Requirements Process

A method for reviewing the requirements process of complex projects

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Preface

When I started this master thesis, I had a few goals. Most of them I have reached. I have increased my knowledge about requirements engineering (RE), I have experienced what it is like to work in a large consultancy company like KPMG and, despite a variety of setbacks (laptops that did not arrive, journals that were not accessible and interviews that kept getting postponed), I have finished the project in approximately six months.

The main aspect I have learned during my master thesis project is that theory and practice are quite different. In the context of my research, I can say that organizations do not spend as much time on the RE phase as theory suggests they should do. The main reason for this is the difference in focus: theory is focused on the quality of the solution, while organizations are mainly focused on cost-efficiency.

During my master thesis project, I have had assistance, guidance and contribution of many people I would like to thank. First, I would like to thank my supervisors from the University of Twente, Klaas Sikkel and Maria Jacob, for their good ideas, valuable advice and the freedom they gave me during this project. I have learned a lot from both of you. Second, I would like to thank my supervisors from KPMG, Sander van der Meijs and Mark Lof, for their time, energy and information sharing. Third, I would like to thank all members of KPMG that have shared their knowledge and experiences about project reviews with me.

Finally, I would like to thank my family and friends for everything they helped me with the last few months. Special thanks go to my grandmother, who gave me the opportunity to live with her during my master thesis project. Thank you all!

March 2011

Mareije Jochemsen

Summary

KPMG IT Advisory frequently reviews the requirements engineering (RE) process as part of a project review. To assist in these reviews, KPMG uses a project-wide method (PRAM) which contains RE specific questions. However, because this checklist only covers a small set of RE specific aspects and is focused specifically on a waterfall model, reviewers often have to fall back on personal knowledge and experience for a complete review. Based on brainstorm sessions with members of KPMG, we have concluded that this necessity to rely on personal experience often results in time-expensive reviews and uncertainty about the completeness of the assessment. Therefore, the goal of this research is to develop a method that focuses specifically on the assessment of the quality of the RE process. To reach this goal, the following research question is answered:

- Which aspects can be used to assess the quality of the RE process for complex software development projects?

A research is performed in order to answer this research question. The complete research is divided into two steps: a preliminary research and a main research. The goal of the preliminary research was to develop an initial version of the RE review method. The preliminary research is based on a literature study and on a study of the current approach. The goal of the main research was to test, improve and validate the developed method. Testing of the developed method is done by a case study of two real-life cases. Subsequently, the results of the tests are used to improve the method. Validation of the improved method is done by six members of KPMG, each with a case study of one real-life case. Based on the validation, conclusions are drawn about the performance of the new method and the new method is adapted accordingly.

The results show us that it is important that the expectations concerning planning, budget and quality of the solution are realized. Therefore, the chances of not realizing these expectations have to be minimized. This can be done by assessing the performance of the RE process as well as the information in the RE documentation. For the review of the RE process, the following aspects are the most important: the scope of the project has to be clear to all stakeholders, roles and responsibilities has to be clearly communicated, an agreement has to be reached about the cost specification, the solution has to be in alignment with the business model and attention has to be paid to the influence of the solution on the business processes. For the review of the RE documentation, the following aspects are the most important: the planning has to be realistic, the planning should contain the right activities, the cost specification has to be realistic, possible risks should be described, and all requirements has to be specified on a high-level as well as on a detailed-level.

The goal of this research is reached. A complete and useful method is developed, with three important benefits in comparison with the current review method: it focuses on assessing the quality of the RE process, it contains aspects that are not present in the current method and it gives examples of aspects where applicable, in order to make the judgment of these aspects easier. The focus of the method is not specifically on iterative processes, but special attention is paid to the aspects that are important in these types of projects.

Samenvatting

KPMG IT Advisory beoordeelt regelmatig het requirements engineering (RE) proces als onderdeel van een project review. Bij deze beoordeling gebruiken ze een projectbrede methode (PRAM), met RE specifieke vragen. Echter, doordat deze methode slechts een klein onderdeel van het RE proces beslaat en is toegespitst op een watervalmodel, moeten reviewers vaak terugvallen op eigen kennis en ervaring. Uit brainstormsessies met werknemers van KPMG is geconcludeerd dat deze terugval op eigen ervaring vaak zorgt voor tijdsintensieve reviews en onzekerheid met betrekking tot de compleetheid van de beoordeling. Daarom is het doel van dit onderzoek het ontwikkelen van een methode die erop gericht is om de kwaliteit van het RE proces te beoordelen. Om dit doel te bereiken is de volgende onderzoeksvraag beantwoord:

- Welke aspecten kunnen gebruikt worden om de kwaliteit van het RE proces voor complexe software ontwikkelprojecten te beoordelen?

Om de onderzoeksvraag te beantwoorden is een onderzoek uitgevoerd. Het complete onderzoek is onderverdeeld in twee stappen: een vooronderzoek en een hoofdonderzoek. Het doel van het vooronderzoek was het ontwikkelen van een eerste versie van de nieuwe methode. Het vooronderzoek bestond uit een literatuurstudie en een studie naar de huidige situatie. Het doel van het hoofdonderzoek was het testen, verbeteren en valideren van de ontwikkelde methode. Het testen van de ontwikkelde methode is uitgevoerd aan de hand van een case studie met twee real-life cases. De testresultaten zijn vervolgens gebruikt om de methode te verbeteren. Validatie van de verbeterde methode is uitgevoerd door zes medewerkers van KPMG, elk aan de hand van een case studie met één real-life case. Op basis van de validatie zijn conclusies getrokken met betrekking tot de prestatie van de nieuwe methode en op basis daarvan is de methode aangepast.

Uit de resultaten blijkt dat het belangrijk is dat de verwachtingen met betrekking tot planning, budget en kwaliteit van de oplossing worden gerealiseerd. De kans op het niet realiseren van deze verwachtingen moet dan ook geminimaliseerd worden. Dit kan bewerkstelligd worden door het beoordelen van zowel de uitvoering van het RE proces als de informatie in de RE documentatie. Voor de beoordeling van het proces zijn de volgende aspecten het meest van belang: de omvang van het project moet helder zijn, verantwoordelijkheden en rollen moeten duidelijk zijn, de begroting moet goedgekeurd zijn door alle belanghebbenden, de oplossing moet in overeenstemming zijn met het bedrijfsmodel en er moet rekening gehouden zijn met de invloed van de oplossing op de bedrijfsprocessen. Voor de beoordeling van de documentatie zijn de volgende aspecten het meest van belang: de planning moet realistisch zijn en de juiste activiteiten bevatten, de begroting moet realistisch, mogelijke risico's moeten zijn afgedekt en alle requirements moeten zijn gespecificeerd op zowel een hoog niveau als een gedetailleerd niveau.

Het doel van het onderzoek is bereikt. Er is complete en bruikbare methode ontwikkeld, met drie belangrijke voordelen ten opzichte van de huidige methode: hij is speciaal gericht op het beoordelen van de kwaliteit van het RE proces, bevat aspecten die niet aanwezig waren in de huidige methode en geeft voorbeelden van enkele aspecten om daarmee het oordeel over dat specifieke aspect makkelijker te maken. De methode is niet speciaal toegespitst op gebruik in een iteratief proces, maar er is wel extra aandacht besteed aan de aspecten die belangrijk zijn voor dit type proces.

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Part I: Introduction

Part I contains information about the organization and about the context of the research. This is done in order to introduce the reader into the topic of the research. It briefly explores the organization, the background, the problem, the research goal, the research questions and the research approach.

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1. Organization

In this chapter, KPMG and its IT Advisory department are introduced. First, the general setting of KPMG will be explored. Second, information about the IT Advisory department will be given.

1.1 KPMG

KPMG is an international network that offers audit, tax and advisory services to clients in more than 140 countries. KPMG is one of the Big Four, along with Deloitte, Ernst & Young and PricewaterhouseCoopers. KPMG was created in 1987, from the fusion of KMG en Peat Marwick International. The name KPMG comes from the names of the four partners who merged their own independent accounting firms: Klynveld, Peat, Marwick and Goerdeler. The global headquarter of KPMG is located in Amstelveen, The Netherlands (KPMG, 2010).

KPMG is specialized in audit, tax and advisory. KPMG Audit offers financial and non-financial audits for large and small clients. KPMG Tax gives advice on risks and opportunities to wealthy individuals as well as to multinationals. KPMG Advisory gives advice to clients about growth, fusions, take-overs, reorganization or other changes. KPMG is active in several areas: financial services, government, healthcare, education, insurance, banking, transport etcetera.

1.2 IT Advisory

IT Advisory is the department that helps clients to identify the internal and external risks of IT-systems, and develops strategies and methods to help them control these risks. An example of an internal risk is that an employee gets access to information that he or she is not allowed to see. An example of an external risk is that people hack an IT-system and get access to sensitive information. IT Advisory helps clients to identify these risks and to develop possible solutions.

Besides identifying risks, IT Advisory helps clients to gain as much as possible from IT-investments, and gives them advice on a strategic and a project level. IT advisory helps clients to connect business goals and IT possibilities by looking at the current and the desired situation and at the changes needed to bridge the gap between them. IT Advisory also develops procedures to realize these changes.

2. Research Problem, Objective and Approach

This chapter contains general information about the research. Consecutively, the following subjects are discussed: background, research problem, research goal, research questions and research approach.

2.1 Background

KPMG IT Advisory frequently reviews projects. As part of a project review, KPMG reviews the requirements engineering (RE) process. The RE process is the first phase of a project and can be defined as the process in which all requirements are identified, analyzed, prioritized and documented.

Davis (1993) argues that the RE process is very important, because of the large impact that requirement conflicts can have on later phases of the project. According to research conducted by Boehm (1981) among 63 software development projects, correcting a requirement conflict in a later phase can cost up to 200 times as much as when it would have been resolved during the RE process.

KPMG recognizes the importance of the RE process, especially in the case of large, complex projects. Complex projects can be defined as large IT projects, concerning several departments, different countries and wide spread customers, resulting in a large amount of (different) stakeholders, each with their own opinion about which requirements have to be taken into account. In these projects, the RE process is complicated by obstacles, such as diversity in processes, country or business unit specific demands, and the absence of direct customer feedback. These obstacles often result in a large list of possibly conflicting requirements from a multitude of sources. The main challenge in the RE process for such projects, is to create a non-conflicting set of requirements that effectively satisfies the needs of the project, without losing support from stakeholders during conflict settlement. This often means splitting requirements into global base lines and local particulars.

2.2 Problem Description

KPMG IT Advisory frequently reviews the RE process as part of a project review. To assist in these reviews, KPMG uses a project-wide methode (PRAM) which contains RE specific questions. However, because this checklist only covers a small set of RE specific aspects and is focused specifically on a waterfall model, reviewers often have to fall back on personal knowledge and experience for a complete review. Based on brainstorm sessions with members of KPMG, we have concluded that this necessity to rely on personal experience often results in time-expensive reviews and uncertainty about the completeness of the assessment.

Because the current method does not satisfy the wishes of the members of KPMG, three members is asked what their opinion is about the aspects that should come back in a method to review the RE process and which of these aspects are missing in the current method. The following missing aspects in the current method came up during these sessions:

- RE process specification, containing the steps in the RE process, the results of each step and the requirements of each step
- RE techniques, containing their application and their advantages and disadvantages in specific situations

- RE document specification, containing the elements of and the quality factors for the RE document

Based on the above, we can conclude that through the absence of a complete and applicable method, time-expensive reviews and uncertainty on the completeness of the assessment are the result. The complete problem description is summarized in the problem bundle in Figure 1.

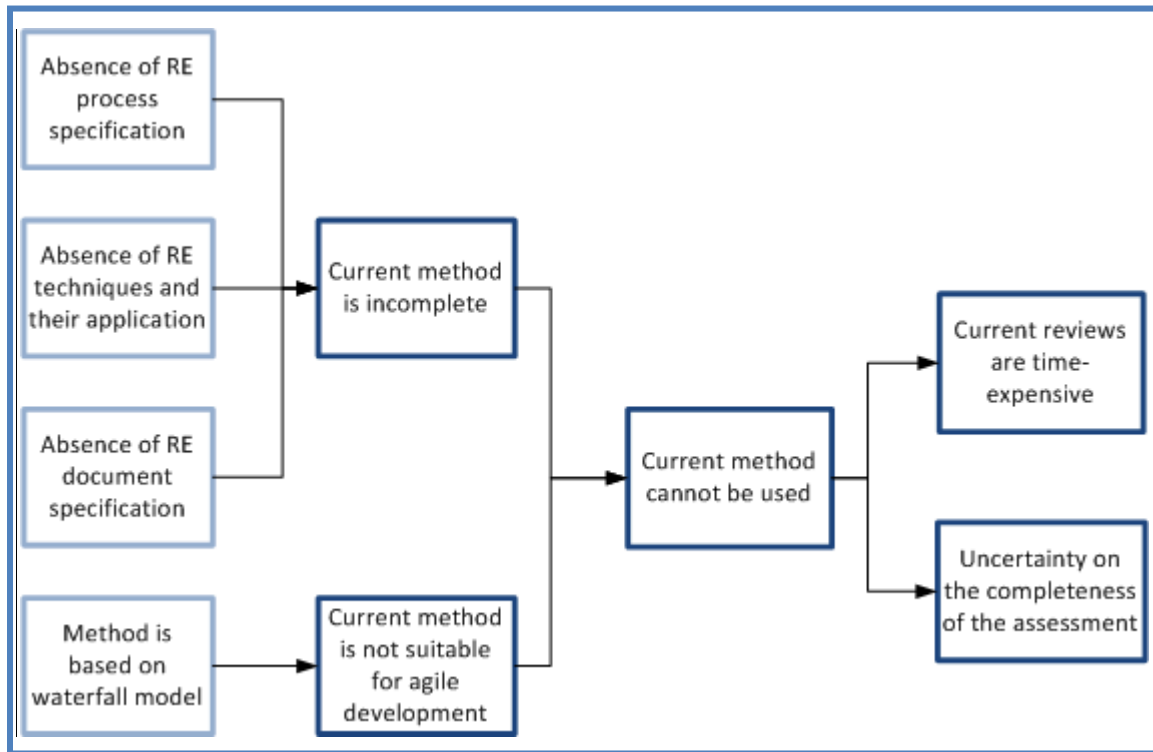


Figure 1. Problem bundle

2.3 Research Goal

KPMG wants to have a method that they can use to assess the quality of the RE process. Therefore, the goal of this research is:

To develop a method that can be used to assess the quality of a RE process.

The practical relevance of this research is the insight KPMG gets into the process of reviewing the RE process. This insight and the desired method can help KPMG improve their RE review process. The insight KPMG gets is important for the review of the RE process, but also for the execution of the RE process; it is easier to perform a good RE process when it is known on which aspects it will be assessed.

The scientific relevance of this research is the insight research get in the aspects that are important for the quality of the RE process. At this moment, no literature is available about a complete set of aspects that is important for this quality. Moreover, no literature is available about a complete set of aspects that can be used to assess the quality of the complete RE process. In this research, information from literature about the review of RE processes is combined with practical experience of KPMG members in order to get the desired knowledge.

2.4 Research Questions

The goal of this project is to develop a method that can be used to assess the quality of the RE process. To reach this goal, the following research question is answered:

Which aspects can be used to assess the quality of the RE process for complex software development projects?

In order to answer the research question, the following sub-questions are formulated:

1. What does the RE process for complex software development projects look like?
2. Which techniques can be used in the RE process and what are the situational characteristics for each technique?
3. What are the requirements for the RE documentation for complex software development projects?
4. Which aspects does KPMG currently use to assess the quality of the RE process?
5. Which aspect should be added to a RE review method to assess the quality of the RE process?
6. To what extent can a method with these aspects be used to review the RE process of complex software development projects?
7. How does such a method score in comparison with the current approach?

2.5 Research Approach

The research is divided into two steps:

- A preliminary research, based on a literature study
- A main research, based on a case study

The goal of the **preliminary research** is to develop a first version of the desired method. This first version of the method is based on the answers of the first four sub-questions. The sub-questions are answered through a literature study and on a study of the current approach. The developed method is tested in the main research in order to find an answer on the main research question.

The goal of the **main research** is to test, improve and validate the method developed in the preliminary research in order to identify which aspects can be used to assess the quality of the RE process. Improvement of the method will be done by checking its relevance, completeness and correctness. This will be done through a case study of two real-life cases. These cases will be provided by KPMG. The results of the case studies will be used to improve the developed method. Subsequently, the improved method will be validated. This will be done by six employees of KPMG through the study of six real-life cases. Based on the validation, conclusions are drawn about the performance of the new method and based on these conclusions, a conclusion is drawn about the aspects that can be used to assess the quality of the RE process. The main research will give an answer to the last three sub-questions and to the main research question.

An overview of the complete research is presented in Figure 2.

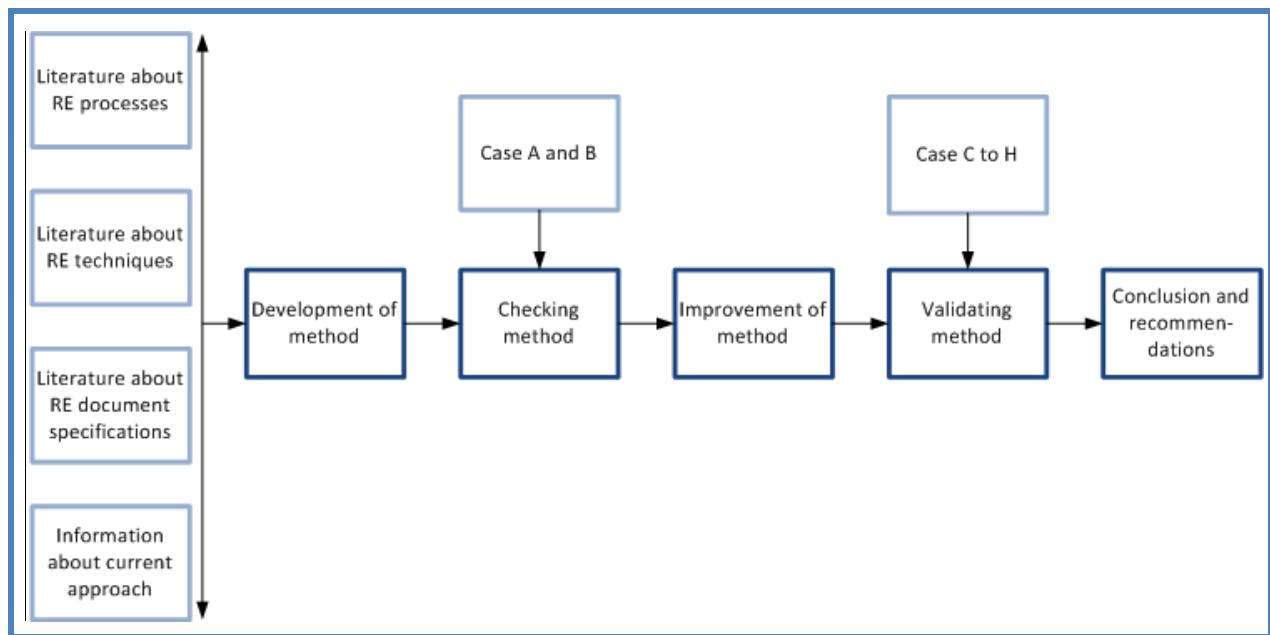


Figure 2. Research approach

3. Structure of the Report

In this chapter, the structure of this report is described. This report exists of five parts, all subdivided into several chapters. Each part is described briefly below.

Part I introduces the research. Part I starts in chapter 1 with the exploration of KPMG, the organization this research is conducted for. Chapter 2 describes the background, the problem, the research goal, the research questions and the research approach. Chapter 3 is the current chapter and describes the structure of the report.

Part II explores the theoretical background. Part II starts in chapter 4 with the exploration of the RE process and contains definitions, the steps in the RE process and the risks in the RE process. Chapter 5 explores the techniques used in the RE process. Chapter 6 explores the RE specification document and contains two document templates and a description of important quality factors. Chapter 7 describes the information already available about the review of the RE process. Chapter 8 provides a summary of the theory.

Part III explores the current situation. Part III starts in chapter 9 with a description of the current review approach of KPMG and recommendations from experts. Chapter 10 provides a summary of the current situation. Chapter 11 describes the proposed method.

Part IV describes the practical insights. Part IV starts in chapter 12 with a description of the research method and contains the description of the eight cases that are used in this research, a description of how data for the different cases is collected, and a description of how the data of the different cases is analyzed. In chapter 13, the results of the analysis of the first two cases, the recommendations based on these results and the new method in which the recommendations are applied are discussed. Chapter 14 gives the results of the analysis of the other six cases.

Part V gives the conclusions and recommendations. Part V starts in chapter 15 with an answer to the research question and gives, subsequently, an explanation to this answer and possibilities for future research. Chapter 16 gives recommendations.

Part II: Theoretical Background

In Part II, the theoretical background of the requirements engineering (RE) process is discussed, as well as the aspects from the theory that can be used to review the RE process. This part provides an answer to sub-questions one, two and three and ends with a summary of the theoretical RE aspects.

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4. The RE Process

In this chapter, the RE process is explored. Consecutively, the following subjects are described: relevant definitions, the steps in the RE process and possible risks. This chapter provides an answer to sub-question one.

4.1 Definitions

In this paragraph, definitions are given for the three most important aspects of the RE process: the RE process, requirements and stakeholders. For each of these terms, a short overview is given of definitions used in the literature, followed by the definition as used in this research.

Requirements engineering (RE) is about bridging the gap between problem and solution. Bray (2002) defines RE as “investigating and describing a problem domain and requirements and designing and documenting the characteristics for a solution system that will meet these requirements”. Zave (1997) defines RE as “the branch of software engineering concerned with the real-world goals for functions of, and constraints on software systems”. Nuseibeh and Easterbrook (2000) define the RE process as “the process of discovering the purpose by identifying stakeholders and their needs, and documenting these in a form that is amenable to analysis”. Based on these definitions, the following definition for the RE process will be used in this research: The RE process is the process in which the problems, goals and requirements of a project are investigated, and in which these and the characteristics for the solution system are designed and documented.

Requirements play a central role in the RE process. Bray (2002) defines requirements as “the effects that the client wishes to be brought into the domain”. Robertson and Robertson (1999) describe requirements as “something that the product must do or a quality that the product must have”. Pfleeger (1998) defines requirements as “a feature of the system or a description of something the system is capable of doing in order to fulfill the system’s purpose”. Based on these definitions, the following definition for requirements will be used in this research: Requirements are the wishes of relevant stakeholders concerning the functionality and quality of a system.

Requirements are supplied by the **stakeholders** of a project. Freeman (1984) describes stakeholders as “any group or individual who can affect or is affected by the achievement of the organization’s objectives”. Nuseibeh and Easterbrook (2000) define stakeholders as “individuals or organizations who stand to gain or lose from the success or failure of a system”. Kotonya and Sommerville (1997) define stakeholders as “the people or organizations who will be affected by the system and who have a direct or indirect influence on the system requirements”. Based on these definitions, the following definition for stakeholders will be used in this research: Stakeholders are the parties that will be affected by the project and who have an influence on the requirements of the project.

4.2 Steps in the RE Process

The RE process is the process in which requirements are identified and in which these and the characteristics for the solution are designed and documented. But what does the RE process generally look like? Many frameworks that describe the RE process are available. Two of them are discussed in this paragraph. These two frameworks are chosen because they are both: good, well known and intelligible.

The first framework describes all steps of the RE process in an understandable way. Therefore, the steps described in this framework are used as a basis in the rest of this research. The second framework describes three dimensions of the RE process from beginning to end. The second framework can be used to look at the maturity of the RE process.

The first framework is developed by Kotonya and Sommerville (1997). Kotonya and Sommerville have developed a spiral model to describe the RE process. The fact that Kotonya and Sommerville use a spiral model to present the RE process, implies that the RE process is iterative and that there is a repetition of the steps in the process until the desired result is obtained.

The spiral model of Kotonya and Sommerville consists of four steps, four results and a decision point. The four steps are:

1. Requirements elicitation
2. Requirements analysis and negotiation
3. Requirements documentation
4. Requirements validation

The first step is **requirements elicitation**. The requirements elicitation is defined by Kotonya and Sommerville (1997) as “the activity that encompasses learning about the problem to be solved, understanding the need of potential users, trying to find out who the user really is and understanding all the constraints on the solution”. Therefore, the following actions are important in this step: stakeholder identification, problem identification, goal identification, constraints identification and the identification and understanding of stakeholders’ needs. This step gives insight in the reasons behind the project and gives information about the direction of the solution. The difficulty in this step lies in the identification of stakeholders’ needs (Lauesen, 2002). Stakeholders often have problems with understanding and formulating what they want, resulting in an unclear understanding of the stakeholders’ needs and in a solution that does not meet the real needs of the stakeholders. The fact that stakeholders are often unfamiliar with new concepts and situations can lead to incorrect or missing requirements. The same applies for the fact that requirements can change during the project. When no stakeholders can be identified, information has to be traced from other sources. The result of this step is an informal statement of requirements.

The second step is **requirements analysis and negotiation**. In this step, a list with requirements is created, conflicts in this list are solved, and the resulting requirements are prioritized. Therefore, the following actions are important in this step: formulation of requirements, specification of requirements, prioritization of requirements and reaching an agreement by stakeholders. Conflicts can arise when different stakeholders have different needs, when requirements are incomplete or forgotten or when the costs of the requirements are above budget (Kotonya & Sommerville, 1997). This step ensures that, at the end of the step, an agreement about the requirements and their prioritization is reached. Therefore, negotiation is important in this step. The difficulty in this step lies in getting all the stakeholders to work together to solve conflicting requirements and to find a balance between all the requirements. The result of this step is an agreement about the requirements.

The third step is **requirements documentation**. In this step, the RE documentation is developed. The documentation provides detailed information about the problems, the requirements and the solution of the project. The result of this step is a draft requirements document. More information about the RE specification document can be found in chapter 6.

The fourth step is **requirements validation**. In this step, the requirements specification document is checked on completeness, consistency, feasibility and testability. Therefore, the following two actions are important in this step: validation of the RE documentation and creation of the validation report. This step is important because conflicts must be identified and solved before the project can enter the next phase. The difficulty in this step lies in the fact that each project is different and that each project has its own specific conflicts, which makes it difficult to find all conflicts. The result of this step is a requirements document and a validation report. The decision point indicates that a decision must be made to accept the current results or to continue the spiral and go back to step one.

The spiral model of Kotonya and Sommerville is presented in Figure 3.

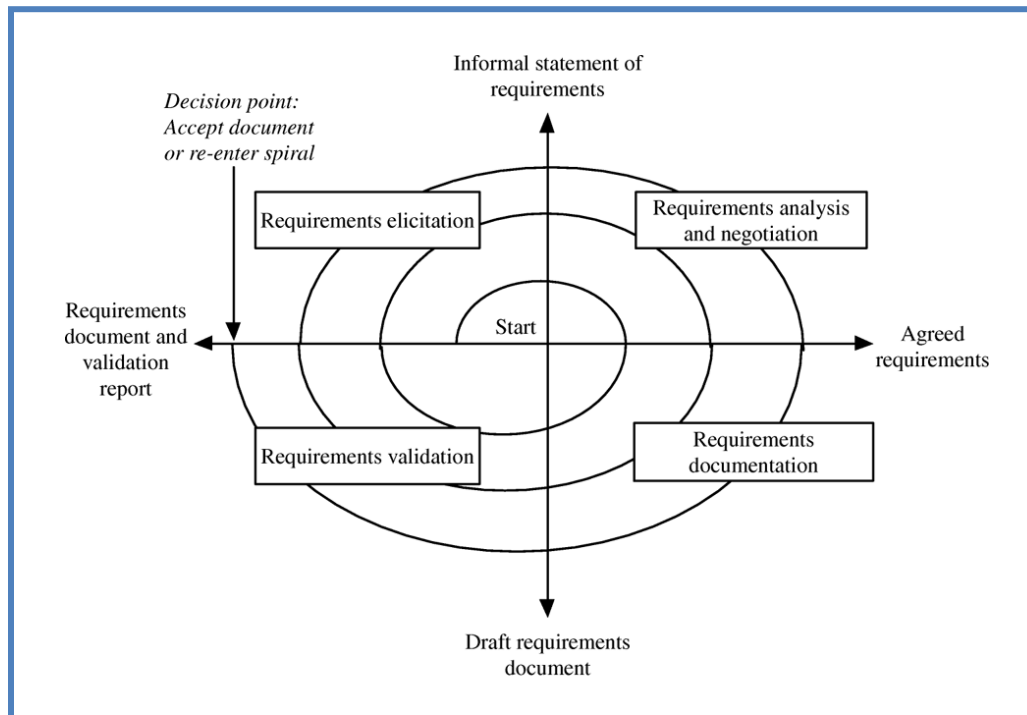


Figure 3. Spiral model describing the RE process (Kotonya & Sommerville, 1997)

The second framework is developed by Pohl (1994). His framework is based on the assumption that each project has an initial input and a desired output, meaning that each project begins with vague personal views and ends with a specification and implementation of a complete and satisfying solution. According to Pohl, the goal of the RE process is getting from the initial input to the desired output. Pohl's framework consists of the following three dimensions:

- Specification

- Representation
- Agreement

The **specification dimension** describes to what extent information about the requirements on the solution is available. The specification dimension ranges from an empty specification to a complete specification. A complete specification is needed to get a clear view on the characteristics of the solution. In order to reach the complete specification, the problem domain and the requirements must be identified. Stakeholders can help to speed up this process by giving clear and understandable information.

The **representation dimension** describes to what extent the specifications have been formalized. The representation dimension ranges from an informal representation to a formal representation. A formal representation is needed to give all parties in the project a clear and correct view on the specification. In order to reach the formal representation, the right formal representation method must be chosen. It depends on the project which method suits best.

The **agreement dimension** describes to what extent common agreement is reached about the requirements specification. The agreement dimension ranges from a personal view to a common view. A common view is needed to deliver a solution that satisfies the wishes of all stakeholders. In order to reach the common view, stakeholders have to work together in reaching the right balance between getting what they want and accepting that other stakeholders get what they want.

As has been said, the RE process is about getting from the initial input to the desired output. Within the three dimensions, the RE process can be described as a curve from the initial input to the desired output. Actions performed to get to the desired output can affect more than one dimension, resulting in a random curve. The dimensions of Pohl, including an example of the RE process, are presented graphically in Figure 4.

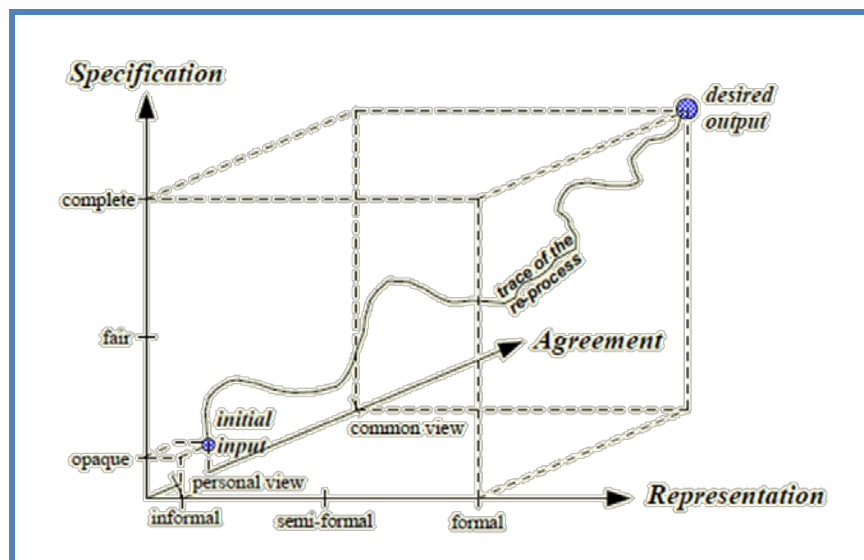


Figure 4. The requirements process within the three dimensions of Pohl (Pohl, 1994)

4.3 Risks in the RE Process

The RE process is a difficult process and a process with many risks of failure. To identify the risks in the RE process, the risk bundle in Figure 5 is developed. The risk bundle is based on the steps and results of the RE process, as they are described by Kotonya and Sommerville (1997), and is completed by adding complementary risks.

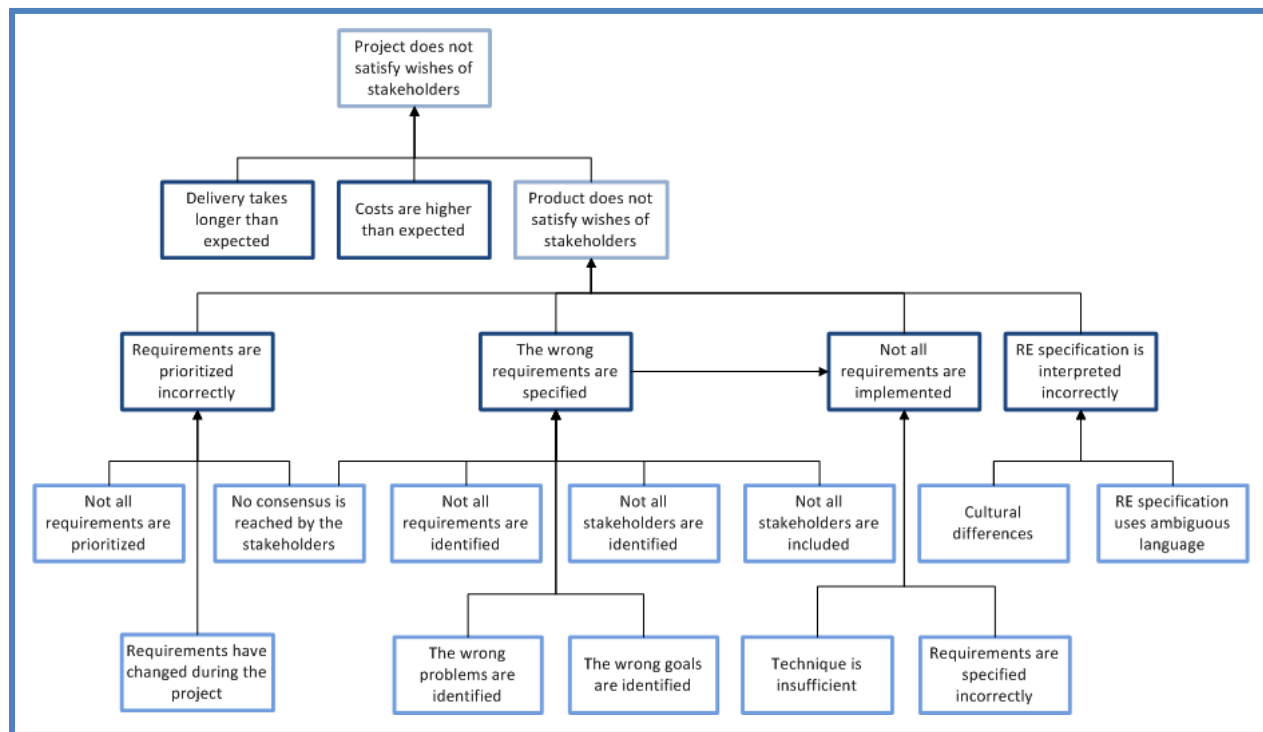


Figure 5. Risk bundle of RE process

The main risk is that **the project does not satisfy the wishes of the stakeholders**. If the product does not satisfy the wishes of the stakeholders, you can say that the project has failed. Three risks influence this risk: the delivery of the product takes longer than expected, the costs of the project are higher than expected and the product does not satisfy the wishes of the stakeholders.

The delivery of the product can take longer than expected when no realistic planning is developed containing all relevant activities and stakeholders.

The costs of the project can be higher than expected when no realistic cost identification is developed that gives all stakeholders insight in the costs.

Four risks can influence that **the product does not satisfy the wishes of the stakeholders**: requirements are prioritized incorrectly, the wrong requirements are specified, not all requirements are implemented and the RE specification is interpreted incorrectly.

Requirements are prioritized incorrectly is a risk in step 2 of the spiral model of Kotonya and Sommerville (1997). It is important that all requirements are prioritized correctly, so that constrained resources may be allocated according to importance and the resulting output can be maximized. It can be

difficult to prioritize all requirements satisfactory. In the context of complex projects, the opinions of a large amount of different stakeholders have to be taken into account, making it more difficult to find a satisfying balance between all the requirements (Lauesen, 2002). It is important to include all stakeholder categories in the RE process to let them reach consensus about the requirements prioritization. Three risks influence this risk: not all requirements are prioritized (risk in step 2), no consensus is reached by relevant stakeholders about the prioritization (risk in step 2), and requirements have changed during the project.

The wrong requirements are specified is a risk in step 3 of the spiral model of Kotonya and Sommerville (1997). It is important that the right problems and goals are identified in order to identify, prioritize and specify the right requirements and in order to make it possible to solve the existing problems. When the wrong problems are identified, the right requirements will not be identified and the real problems will not be solved. Six risks influence this risk: not all stakeholders are identified (risk in step 1), not all stakeholders are included in the project (risk in step 1 and 2), not all requirements are identified (risk in step 1), no consensus is reached by relevant stakeholders about the requirements specification (risk in step 1 and 2), the wrong problems are identified (risk in step 1) and the wrong goals are identified (risk in step 1).

Three risks can influence that **not all requirements are implemented**: the technique is insufficient, requirements are specified incorrectly (risk in step 3) and the wrong requirements are specified.

RE specification is interpreted incorrectly is a risk in step 4 of the spiral model of Kotonya and Sommerville (1997). The RE specification should be unambiguous and interpreted in the same way by different persons. This is important to avoid misunderstandings between stakeholders and developers of the product. Two risks influence this risk: ambiguous language is used and there are cultural differences influencing the interpretation of specific information.

The risks with the dark blue frame are referred to in the proposed method.

5. Techniques used in the RE Process

In this chapter, the techniques used in the RE process are explored. Techniques are the structured ways in which an action can be performed. Each step in the spiral model of Kotonya and Sommerville (Kotonya & Sommerville, 1997), as described in paragraph 4.2, has its own techniques. In this chapter, the following categories of techniques are described: stakeholder identification techniques (step 1), elicitation techniques (step 1 and 3), prioritization techniques (step 2) and documentation techniques (step 3). For step 4, no specific techniques are discussed in this chapter; chapter 6 describes the characteristics of a RE specification document.

For each of the above categories, only a selection of the available techniques are discussed. The techniques described here are chosen because of their reputation and their difference in properties (such as goals, steps and/or constraints). This chapter provides an answer to sub-question two.

5.1 Stakeholder Identification Techniques

Several techniques are available to identify stakeholders. The six techniques in Figure 6 are described in this paragraph. The first three techniques are techniques for stakeholder identification. They are defined by Reed et al. (2009) and assume that at least one stakeholder is known. The fourth technique can be used when no stakeholder is known. The last two diagrams, from Chevalier and Buckles (2008) and Mitchell, Agle and Wood (1997), can be used to categorize stakeholders.

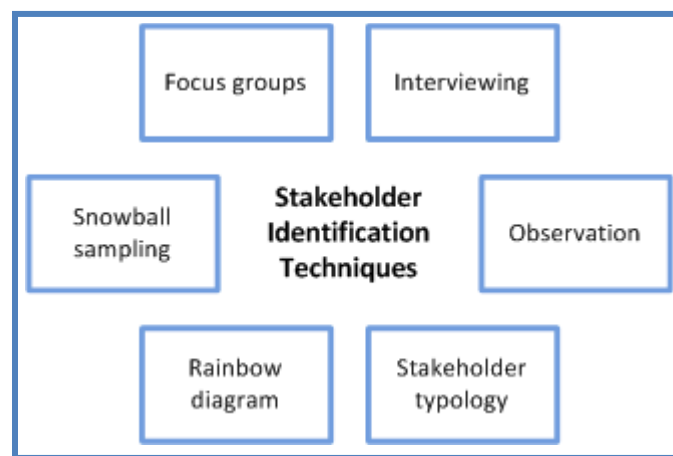


Figure 6. Stakeholder identification techniques

Focus groups are small groups of people brainstorming about a specific subject. In the context of this research, relevant stakeholders can brainstorm, deliberate choices and reach consensus about all aspects connected to the project, including the different (categories of) stakeholders that have to be involved in the project (Reed, et al., 2009). This technique assumes that at least one stakeholder is known. In order to set up a focus group, a few things have to be arranged: a room where the focus group can meet, transport to this place, a conversation leader and a day and time all people are able to meet. A positive aspect of focus groups is that understanding and consensus about complex information in a group of people can be reached. Therefore, focus group can be used to discuss and reach consensus about complex information. A negative aspect of focus groups is that people have to meet, resulting all of the

usual meeting related difficulties, such as finding a suitable time and location given the different group members' travel times and schedules and the difficulty in the arrangement of meeting with a group.

Interviewing focuses on receiving and discussing information of specific subjects with one individual or with a few members of a group. Discussing information can be important when going into detail about information or to check if information (of the focus groups) is correct and complete (Reed, et al., 2009). This technique assumes that at least one stakeholder is known. Several interview techniques can be distinguished: face-to-face interviews, telephone interviews, email interviews, instant message interviews (Opdenakker, 2006) and video interviews. Positive aspects of interviews are that it is possible to go into detail about each subject and that it is possible to respond directly on interesting answers. Therefore, interviews can be used when detailed information is needed from one individual or from a group. Today, it is no longer required to travel to another individual for an interview, making interviewing a good technique to receive and discuss information with parties that live far away. A negative aspect of interviewing is that you speak to only one individual at a time, resulting in a time-consuming process and difficulty in reaching consensus between relevant stakeholders (Reed, et al., 2009). Therefore, interviewing is advised against as a tool for reaching consensus between multiple persons.

Snowball sampling means that a few individuals of different categories of stakeholders are interviewed in order to find other (categories of) stakeholders (Reed, et al., 2009). Subsequently, the new stakeholder categories are interviewed until all stakeholder categories are identified. This technique assumes that at least one stakeholder is known. A positive aspect of snowball sampling is that a minimum of interviews is needed, because only one or a few individuals of each category are interviewed. Therefore, snowball sampling can be used when there is a limited amount of time. A negative aspect of snowball sampling is that each of the individuals that is interviewed has a large influence on the direction of the project.

Each business has its own cycle of events and this cycle can be used to identify stakeholders (Sharp, Finkelstein, & Galal, 1999) or to receive information about the current situation (Lauesen, 2002).

Observation means watching a specific real-life situation in a specific period. It can be unclear who the stakeholders are and stakeholders can have problems with explaining what tasks they perform and why they perform these tasks. Observation can help to complete and correct these views. This technique can be used when no stakeholder is known. Moreover, a positive aspect of observations is that it is possible to find out what is really going on. A negative aspect of observations is that only a specific period in time is observed, giving the possibility that critical issues are overlooked. This can be solved partly by increasing the observation period and by repetition.

Stakeholders can be classified according to different categories. Two categories will be described. The first is from Chevalier and Buckles (2008). They recommend classifying stakeholders according to the degree they can affect or are influenced by the project. They developed a **rainbow diagram** to make this categorization easier. An example of their rainbow diagram can be found in Figure 7.

The second is from Mitchell, Agle and Wood (1997). They recommend classifying the stakeholders according to the degree they have the attributes power, legitimacy and urgency present. Having one of the attributes means that stakeholder salience is low. Having all three of them means that stakeholder

salience is high and that the opinions of these stakeholders are very important. An example of the **stakeholder typology** of Mitchell, Agle and Wood can be found in Figure 8.

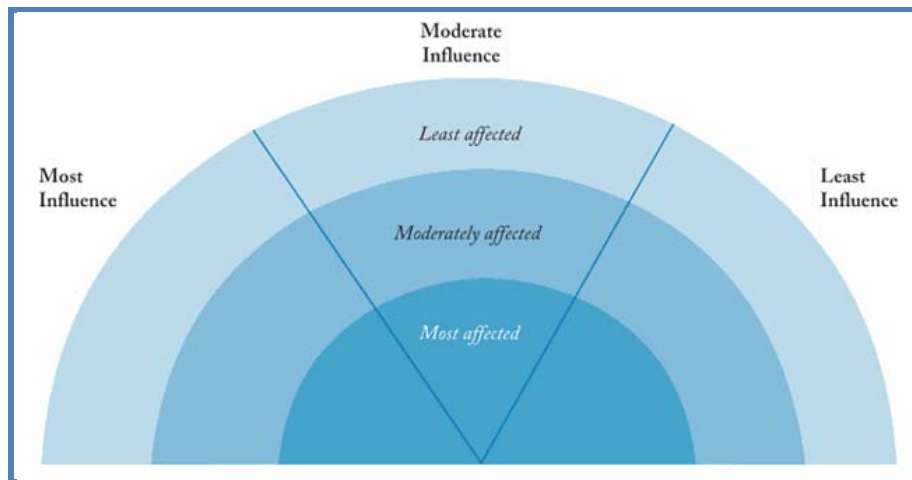


Figure 7. Classifying stakeholders according to the degree they can affect or are influenced by a project (Chevalier & Buckles, 2008)

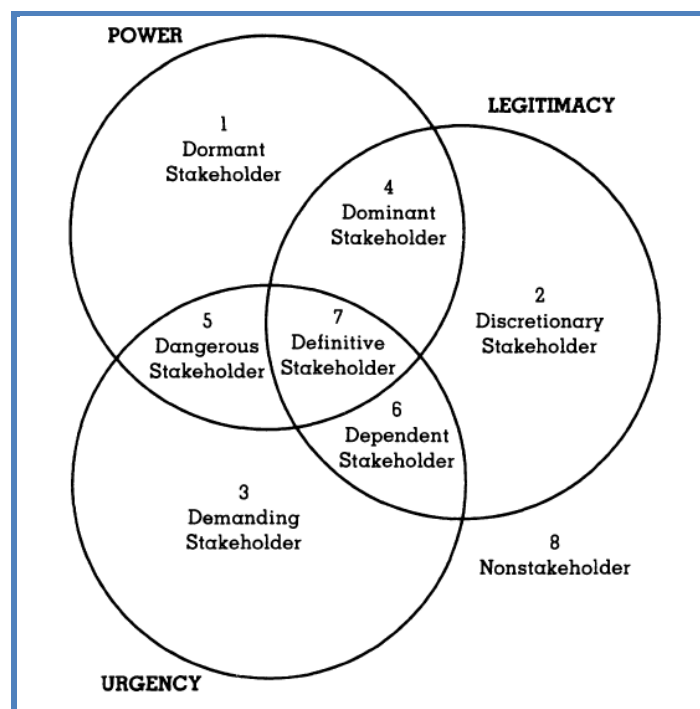


Figure 8. Classifying stakeholders according to the degree they have power, legitimacy and urgency (Mitchell, Agle, & Wood, 1997)

5.2 Elicitation Techniques

To identify and collect information, such as problems, goals, constraints and stakeholders' needs, many techniques are available. The first seven techniques that are discussed can be used to identify information and reach consensus through discussion. The last four techniques can be used to show future

users how information is interpreted, to show what the solution would look like with the current requirements and to provide material for a discussion. Combinations of techniques are also possible: focus groups can, for example, be used to discuss a prototype. The techniques that are described are shown in Figure 9.

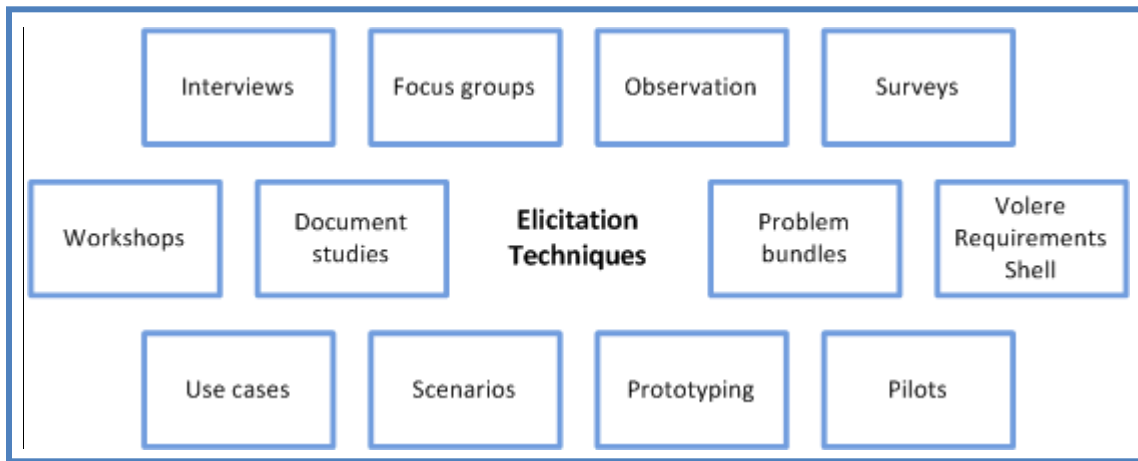


Figure 9. Elicitation techniques

Interviews, focus groups and observations are already discussed with the stakeholder identification techniques. The only difference is the subject of the discussions, as it is no longer restricted to stakeholder identification.

Surveys are written questionnaires that are spread under a large percentage of individuals. Surveys can be used to retrieve information about the current situation, the problem domain and the stakeholders' goals (Lauesen, 2002). A survey can contain both open and closed questions. A positive aspect of a survey is that it focuses on retrieving information from many people simultaneously. A negative aspect of surveys is that the available questions are fixed; it is not possible to react to interesting or unexpected answers.

In **workshops**, individuals are asked to participate and to give input on a regular basis. Workshops can be used to provide stakeholders, such as users and engineers, with practical information. In workshops information about the proposed solution can be discussed, questions can be asked and opinions can be given. A positive aspect of workshops is that all participants are actively involved in thinking and discussing about the current situation and about possible solutions. Negative aspects of workshops are that a meeting with many people has to be arranged and that it can be difficult to keep all stakeholders engaged during the workshop.

Document studies focus on the study of documents used by the organization (Robertson & Robertson, 1999). This technique should be used in conjunction with other techniques, such as interviews. Positive aspects of studying documents are that it offers a way to profit from past and possibly forgotten (but documented) experiences and to construct an objective background context for the project. Negative aspects of studying documents are that information in documents is dated (and may contain no information about current developments) and that it is a time-extensive technique.

Problems bundles are systematic ways to find and document problems and their sub-problems. Problem bundles look like mindmaps: they show problems, sub-problems and the relations between problems. As an example, see the problem bundle of this research in Figure 1. A positive aspect of problem bundles is that they simplify problem identification. A negative aspect of problem bundles is that a single problem bundle can grow very large when there are many problems.

The **Volere requirements shell** is developed by Robertson and Robertson (1999) to identify and document information about requirements. The shell provides a structured way to identify and document all information related to specific requirements. The positive aspect of the shell is that it offers an up-to-date overview of gathered and missing information. This allows the elicitation process to be spread over multiple sessions. The Volere requirements shell, including a description of the elements in the shell, is shown in Figure 10.

Requirement #:	Unique Id	Requirement Type:	Template section	Event/use case #:	Origin of the requirement
Description:	A one-sentence statement of the intention of the requirement				
Rationale:	Why is this requirement considered important or necessary?				
Source:	Who raised this requirement?				
Fit Criteria:	A quantification of the requirement used to determine whether the solution meets the requirement.				
Customer Satisfaction:	Measures the desire to have the requirement implemented		Customer Dissatisfaction:	Unhappiness if it is not implemented	
Dependencies:	Other requirements with a change effect		Conflicts:	Requirements that contradict this one	
Supporting Materials:	Pointer to supporting information				
History:	Origin and changes to the requirement				
					Volere <small>Copyright © Atlantic Systems Guild</small>

Figure 10. The Volere requirements shell (Robertson & Robertson, 1999)

Use cases describe the actors and objects that have to work with the system and the actions they can perform with it. Moreover, use cases show what actions are performed by the system and what actions have to be performed by the user (Robertson & Robertson, 1999). In order to build use cases for a project, the product has to be divided into units of work. For each of these units, events and their actions can be formulated. Use cases can be presented graphically in UML diagrams or textually in tables. A positive aspect of use cases is that they are easy to understand. A negative aspect of use cases is that the number of use cases grows strongly with the size of the project.

Scenarios are case studies illustrating possible situations (Lauesen, 2002). Scenarios in this context can be about current situations and about the solution. So called ‘what if’ scenarios can be used to reveal possible exceptions to previously held assumptions. From these exceptions, more requirements can be derived (Robertson & Robertson, 1999). A positive aspect of scenarios is that it offers a platform to

discuss the consequences of the solution on the business processes. A negative aspect of scenarios is that it can be time-consuming to design and build a scenario.

Prototypes are models of new products and can be used to give stakeholders an idea of how the solution would work in real life (Lauesen, 2002). Moreover, prototypes make the product real enough to help users discover requirements that might otherwise be missed (Robertson & Robertson, 1999). Therefore, prototyping is very important in many types of projects. Two types of prototype can be distinguished: low fidelity and high fidelity (Robertson & Robertson, 1999). Low fidelity prototypes provide a simple view of the new product, are usually visualized on paper, whiteboards, post-it notes etc, and therefore cheap to build or change. High fidelity prototypes give a more realistic view of the new product, are programmed to provide some (possibly limited) functionality and can therefore be time-consuming to build or change. Positive aspects of prototyping are that stakeholders can see elements of the proposed solution, ask questions about it and give their opinion in order to improve in an early stage.

Pilots are small scale implementations of the solution in order to test (a part of) it in a real life situation. In the context of complex projects, pilots can, for example, be executed in a single department or country. The results of a pilot can be used to improve the solution before full scale implementation. A positive aspect of pilots is that stakeholders can test the solution in real-life, ask questions about it and give their opinion in order to improve the solution. A negative aspect of pilots is that they can be time-consuming to set them up or to change them when necessary. However, when concerning the costs of changing a product when it is implemented completely, the benefit of executing a pilot first far outweighs its costs.

5.3 Prioritization Techniques

To prioritize information, many techniques are available. The four techniques that are shown in Figure 11 are described in this paragraph. The first three techniques are described by Berander and Andrews (2005), the last one is a technique to prioritize requirements on multiple criteria.

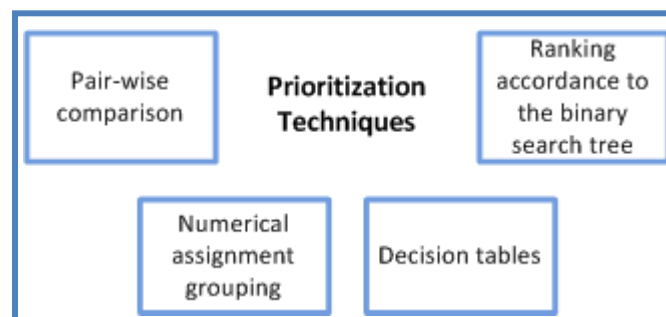


Figure 11. Prioritization techniques

Pair-wise comparison means that every possible pair of requirements is compared in order to identify which one of the two has a higher priority and to what extent (Berander & Andrews, 2005). However, when the number of requirements grows, the number of pair-wise comparisons increases dramatically (Karlsson, Wohlin, & Regnell, 1998). A positive aspect of pair-wise comparison is that the prioritization is accurate and that the resulting weighted list offers an indication of the differences in relative importance.

A negative aspect of pair-wise comparison is that it is very time-consuming and therefore not suitable for large projects.

Ranking means that the requirements are ranked from most important to least important, thus from 1 to n (number of requirements) (Berander & Andrews, 2005). This means that every requirement has a unique ranking. This can be accomplished using any one of the many sorting mechanisms employed in information sciences, such as a binary search tree. A positive aspect of ranking is that each requirement gets a unique ranking. This simplifies the decision process when there are not enough resources to implement all requirements. A negative aspect of ranking is that it can be difficult to give requirements a unique number, because the comparison criteria tend to be (partially) subjective and may at times even be contradictory when supplied by different stakeholders.

The **numerical assignment grouping** focuses on grouping the requirements into different priority groups (Berander & Andrews, 2005). Here, it is important that there is a clear definition of each group. The groups can, for example, be defined as low, medium and high priority groups (Karlsson, Wohlin, & Regnell, 1998). Moreover, restrictions about the number or percentage of requirements in each group are necessary in order to avoid the group 'high priority' to become too large (Berander & Andrews, 2005). Positive aspects of numerical assignment are that it is an easy technique to use and that it is a quick technique to prioritize requirements. A negative aspect of numerical assignment is that requirements do not get a unique priority (requirements are prioritized in groups), making the prioritization less precise.

Decision tables can be used to evaluate, compare and rate different requirements on multiple criteria. With decision tables, an overview of the requirements and their properties can be given. Furthermore, requirements do not have to be compared with one another; each requirement is judged on its own properties. Moreover, new requirements can also be added easily as they do not have to be compared with the other requirements. Therefore, decision tables are useful in projects with many requirements. A positive aspect of decision tables is that multiple criteria can be used to prioritize the requirements and that new requirements or changes can be applied easily. A negative aspect of decision tables is that these criteria also need to be prioritized, because not all of them would have the same priority.

5.4 Requirement Documentation Techniques

To document information, several techniques are available. The first six techniques are diagram types that can be used to describe information about the system, its functions and attributes, and the data flow. The last two techniques are techniques that can be used to identify and document information. The techniques in Figure 12 are described:

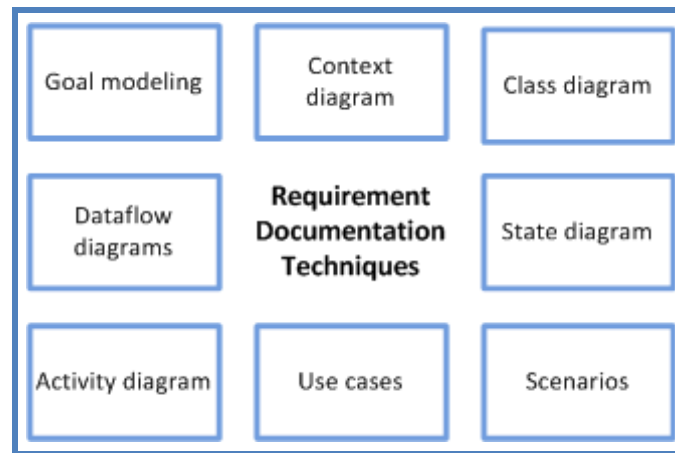


Figure 12. Requirement documentation techniques

Goal modeling is the modeling of goals in order to understand the current situation, define current goals and define the desired situation (Kavakli & Loucopoulos, 2003). Goals can be described using informal, semi-formal and formal representation techniques. Informal goal modeling means that goals are described in text. Semi-formal goal modeling means that goals are described in box- and arrow diagrams. Formal goal modeling means that logical assertions are described in a formal specification language. Positive aspects of goal modeling are that it can be used to check if all goals are reached with the solution, to check if there are no irrelevant requirements (in other words: to check if all requirements are connected to at least one goal) and to give an overview from high-level objectives to low-level technical requirements (Van Lamsweerde, 2001). An example of a goal-oriented RE approach is KAOS (Dardenne, Van Lamsweerde, & Fickas, 1993). The main goal of the KAOS methodology is to describe the problem domain, to identify and structure the requirements and to provide an easy and efficient way for stakeholders to communicate. The result of the KAOS methodology is a requirements model, and a requirements specification document based on this model.

Context diagrams give a high-level overview of the solution. Context diagrams show the system as a black box, and show the system's connection with actors and external systems, with which the system communicates (Lauesen, 2002). A positive aspect of context diagrams is that they show the solution in its environment. A negative aspect of context diagrams is that they do not go into detail.

Class diagrams present the structure of a system by showing classes, class attributes, class methods and the relations and dependencies between the different classes. In other words, class diagrams show the complete system in detail. A positive aspect of class diagrams is that they show the structure of the complete system in detail. A negative aspect of class diagrams is that they grow strongly with the size of the project.

Dataflow diagrams show the functions of a system and the dataflow between the functions (Lauesen, 2002). They show the data input of each function as well as the data output. A positive aspect of dataflow diagrams is that the data need of each function can be identified. A negative aspect of dataflow diagrams is that data flows cannot be associated explicitly with an event.

State diagrams show how one state can change to another state by means of events (Lauesen, 2002). State diagrams give insights in the possible states of a system and the events that can happen. A positive aspect of state diagrams is that they are easy to read, even when they are very large. A negative aspect of state diagrams is that it can be difficult to include all events in one structured diagram.

Activity diagrams show which activities are executed consecutively and what data is transported between these activities (Lauesen, 2002). A positive aspect of activity diagrams is that they give details about the structure of large systems and about the communication between different parts of the system and between different systems. A negative aspect of activity diagrams is that they can become very large, because they are so detailed.

Use cases and scenarios are discussed with the information identification techniques.

6. The RE Specification Document

In this chapter, the requirements for the RE specification document are explored. First, commonly used documentation templates are described. Second, quality factors for the RE document are given. This chapter provides an answer to sub-question three.

6.1 Document Templates

Several templates that describe the RE specification document are available. Two requirements specification templates will be described: the Volere template and the IEEE standard 830-1998. These two templates are selected because of their good reputation.

The Volere template is a commonly used framework for requirements specification (Robertson & Robertson, 1999). The template is known for its completeness and ease of use. The template describes: the product constraints including the purpose, users and constraints; the functionality of the product including the functional and data requirements; the qualities of the product, including the performance and usability requirements; and project issues like risks and costs.

A summary of the template is presented in Figure 13.

Item	What the item describes
Project constraints	Restrictions and limitations of the project
1. The purpose of the product	Motivation and advantages of the project
2. Clients, customers and other stakeholders	Parties interested in the project
3. Users of the product	End-users
4. Requirements constraints	Limitations and restrictions of the project
5. Naming conventions and definitions	Vocabulary of the project
6. Relevant facts	Outside influences on the project
7. Assumptions	Assumptions made about the project
Functional requirements	The functionality of the product
8. The scope of the product	Boundaries of the product
9. Functional and data requirements	Functionality and dataflow of the product
Non-functional requirements	The qualities of the product
10. Look and feel requirements	Appearance of the product
11. Usability requirements	Usability of the product
12. Performance requirements	Performance of the product (how fast, reliable etc.)
13. Operational requirements	Interaction with environment of the product
14. Maintainability and portability requirements	Maintainability and portability of the product
15. Security requirements	Confidentiality, integrity and availability of the product
16. Cultural and political requirements	Cultural and political factors
17. Legal requirements	Compliance with applicable laws
Project Issues	Issues of the project
18. Open issues	Things that are still unclear

19. Off-the-shelf solutions	Alternatives to the product in development
20. New problems	Problems that the product introduces
21. Tasks	Tasks to implement the final product
22. Cutover	Tasks to convert from other systems
23. Risks	Possible risks of the project
24. Costs	Estimated costs of the complete project
25. User documentation	Plan to develop instructions and documentation
26. Waiting room	Optional requirements for future releases

Figure 13. The Volere template of Robertson and Robertson

The **IEEE standard 830-1998** is developed in 1998 to describe the content and qualities of software requirements specifications (SRS) (IEEE Std. 830, 1998). The template describes: an overview of the complete SRS including purpose and goals; the background of the project including users and constraints; and all requirements of the complete solution, including functional and performance requirements.

A summary of the template is presented in Figure 14.

Item	What the item describes
Introduction	Overview of the complete SRS
1. Purpose	Purpose and audience of the project
2. Scope	The product, its functionality, benefits and goals
3. Definitions, acronyms and abbreviations	Information for interpretation of the SRS
4. References	All references
5. Overview	Content and organization of the SRS
Overall description	Background of requirements
6. Product perspective	Operating within constraints
7. Product functions	Summary of major functions
8. User characteristics	General characteristics of end-users
9. Constraints	Items limiting developer's options (safety etc.)
10. Assumptions and dependencies	Factors that can affect requirements
Specific requirements	All product functionalities in detail
11. External interface requirements	All inputs and outputs of the product
12. Functional requirements	Functionality of the product in detail
13. Performance requirements	Performance of the product in detail
14. Design constraints	Requirements from existing standards or regulations
15. Software system attributes	Attributes of requirements (reliability, security etc.)
16. Other requirements	Other requirements applying the product

Figure 14. The IEEE 830 template

6.2 Quality Factors

The RE documentation should contain specific elements, but the requirements should also satisfy a specific quality. According to the IEEE 830 standard, the requirements specification should satisfy eight qualities (IEEE Std. 830, 1998). These eight qualities are shown in Figure 15.



Figure 15. Quality factors from the IEEE 830-1998

Correctness means that requirements are correct, up-to-date, and that they are updated when the situation changes. Correctness is important in order to implement the right requirements.

Unambiguous means that each requirement has only one interpretation. This is important in order to avoid misunderstandings between stakeholders and between stakeholders and architects.

Completeness means that the RE document contains all requirements that are needed to develop the solution. Completeness is important in order to develop a product that satisfies the needs of all stakeholders.

Consistency means that the same names and abbreviations are used for the same objects. This is also important to avoid misunderstandings between stakeholders and between stakeholders and architects. Consistency should hold within the requirement itself and between requirements.

Ranked for importance means that the requirements are prioritized. This is, as mentioned in paragraph 4.2, important in order to decide which requirements are mandatory and which requirements are optional.

Verifiability means that requirements are formulated in such a way that they can be tested easily after implementation. The verifiability of requirements is important to allow easy evaluation.

Modifiability means that the requirements are easy to change. This is important in order to go along with iterative development projects.

Traceability means that it is clear where requirements come from and why they are so important. In other words, it is important that the documentation contains information about for which stakeholders the requirement is important and why the requirements have to be implemented.

7. Review of a Software Development Project

This chapter contains information about reviewing a software development project. Project reviews give the organization and the stakeholders of a project insight into the quality of the process and into its results. The following subjects are described in this chapter consecutively: review of a complete project and the review of the RE process of a project.

7.1 Review of a Complete Project

To review a complete project, it is important to look at different parts of a project as well as at the complete project. There are several ways to divide a project into individually reviewable parts. A common division is the following:

- Requirement specification
- Individual deliverables
- Product implementation

After the **requirement specification**, the requirements can be reviewed by all relevant stakeholders. At the end of this review, and after changing the requirements in order to fulfill the wishes of all stakeholders, an agreement about the requirements (and their prioritization) is made (Kotonya & Sommerville, 1997).

After **individual deliverables** are finished, these deliverables can be reviewed. Reviewing deliverables of the product before implementation helps to make sure that the end product still satisfies the wishes of the stakeholders. When changes have to be made (requirements can have changed during the project), it is easier to make them before the product is in use. Reviewing deliverables can be done by checking that they satisfy the requirements formulated in the RE documentation and the wishes of the stakeholders.

After **product implementation**, the complete product can be reviewed. This can also be done by checking that the product satisfies the requirements formulated in the RE documentation, and by checking that the product satisfies the wishes of the stakeholders.

After finishing the project, the complete project can be reviewed. This can be done by checking if the project satisfies the wishes of the stakeholders. As already is seen in the risk bundle in Figure 6 (see paragraph 4.3), three things are important for a project to satisfy the wishes of the stakeholders: delivery of the project must not exceed the estimated time, the project must not exceed the estimated costs, and the product must satisfy the wished of the stakeholders.

7.2 Review of the RE Process

No method is available for reviewing the complete RE process. However, the RE process is iterative and has a decision point in the spiral model that indicates when the decision must be made to accept the requirements documentation or to re-enter the spiral model (Kotonya & Sommerville, 1997). You can say that this decision point is the point in the RE process at which the review of the RE process is performed by its stakeholders. The RE process will be repeated until all relevant stakeholders have agreed on the requirements documentation.

A review of the RE process does not only exist of a review of the requirements documentation by its relevant stakeholders. In theory, the aspects that can be used to check the performance of the RE process are not complete, and the aspects that are known are not combined into a method.

8. Use of the Theory

The most important aspects from Part II are summarized in Figure 16.

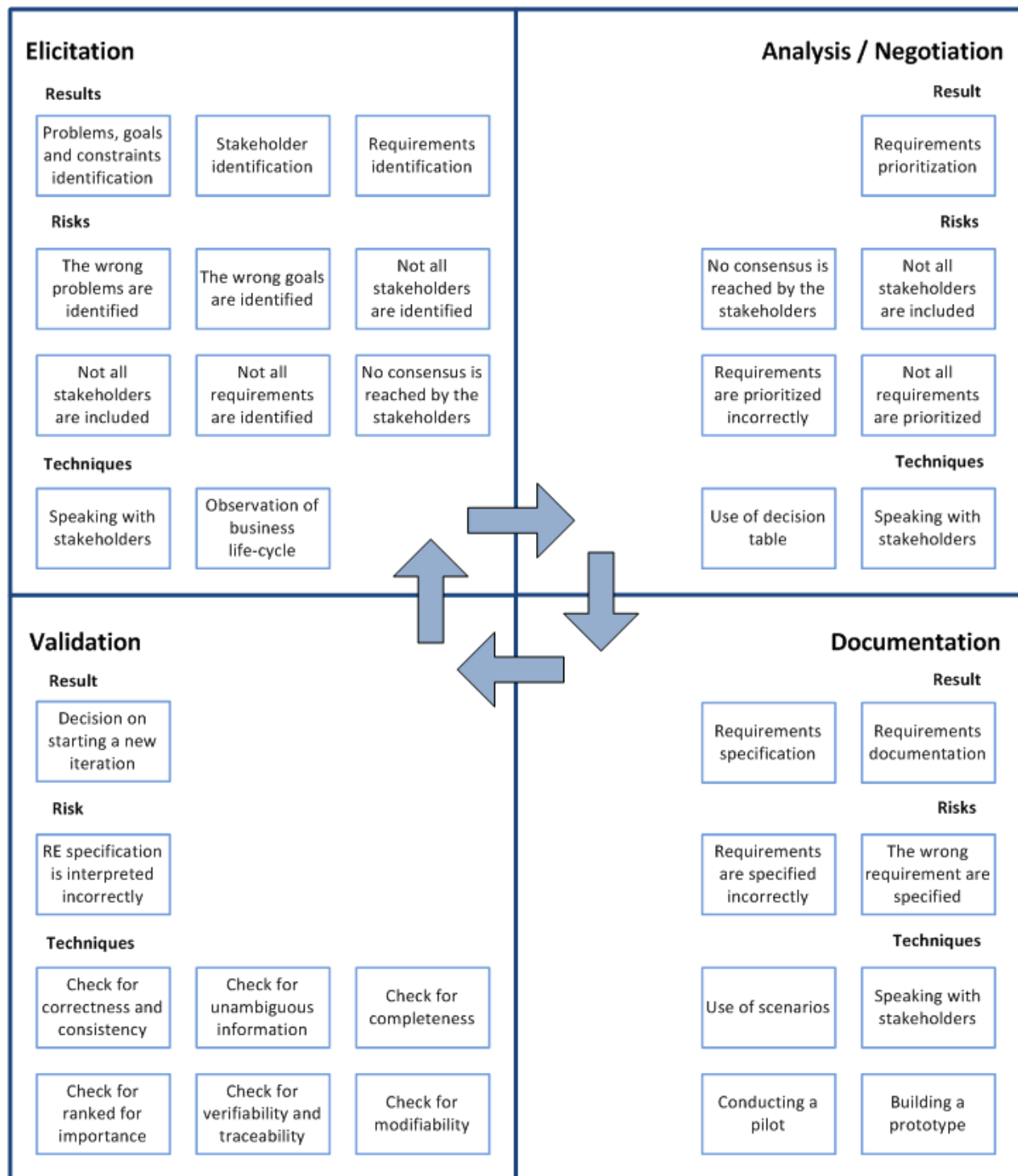


Figure 16. Summary of theoretical background

The information in Figure 16 is divided into the four steps of the RE process: elicitation, analysis and negotiation, documentation and validation. For each step, the results, risks and possible techniques are given.

The result of **step one** is the identification of problems, goals, constraints, stakeholders and requirements. The main risks in this step are that the wrong problems are identified, that the wrong goals are identified, that not all stakeholders are identified, that not all stakeholders are included, that not all requirements are identified and that no consensus is reached by the stakeholders. In this step, it is important to speak with stakeholders about their problems and needs and to observe relevant events in the business life-cycle to identify problems and stakeholders.

The result of **step two** is a requirements prioritization. The main risks in this step are that not all stakeholders are included, that no consensus is reached by the stakeholders, that not all requirements are prioritized and that the requirements are prioritized incorrectly. In this step, it is important to speak with stakeholders about the prioritization and to make use of a decision table to create an overview of the requirements and their priorities.

The result of **step three** is a complete requirements specification and a requirements documentation. The main risks in this step are that the wrong requirements are specified and that the requirements are specified incorrectly. In this step, it is important to speak with stakeholders about their specific needs, to use scenarios to get an idea about how the solution will influence the work of the user, to build a prototype to make the solution real enough for possible users to come up with missing requirements and to conduct a pilot to test if the product will work as expected and if it encloses the needs of all stakeholders.

The result of **step four** is the decision on starting a new iteration. The main risk in this step is that the RE specification is interpreted incorrectly. In this step, it is important that the documentation is correct, consistent, unambiguous, complete, ranked for importance, verifiable, traceable and modifiable.

Recall that the RE process is an iterative process. In Figure 16, this is shown by the arrows in the center of the diagram. For the development of the method, it is important that the steps are executed as many times as needed in order to receive the desired result.

The result of Part II is used to develop a first version of the RE review method in chapter 11. Because theory alone is not enough to build a complete review method, the current review method of KPMG will also be explored. The results of this exploration can be found in Part III.

Part III: Current Situation

Part III contains information about the current RE review approach of KPMG and describes recommendations from several experts. Subsequently, a summary of the current situation is given. This part provides an answer to sub-question four and ends with the description of the proposed method.

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9. Current Review Approach of KPMG

This chapter contains information about the current method KPMG uses for the review of the RE process and about the opinion of experts from KPMG.

9.1 Current Method

At this moment, KPMG uses the following two elements for the review of the RE process of complex projects:

- A project-wide method (PRAM) which contains RE specific aspects
- Knowledge and experience of KPMG's IT audit members

KPMG has a method that can be used to review a complete project. This method contains high-level aspects that check the RE process. The aspects in this method are based on a waterfall model and are therefore less relevant for projects in which the RE process is completely iterative. The RE aspects in the method are based on the ten subjects shown in Figure 17.

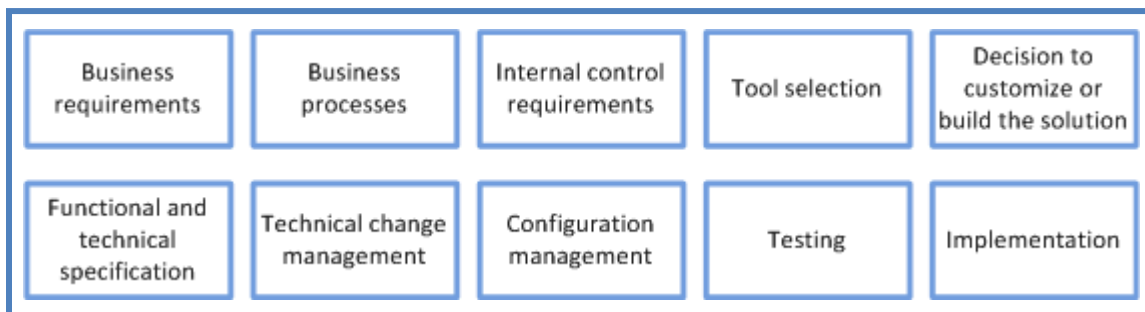


Figure 17. Subjects described in the current review method

Business requirements describe the identification, formulation and documentation of the business requirements. To identify all business requirements, all relevant stakeholders and their expectations have to be identified and the needs of the organization have to be understood and communicated to all the stakeholders. Conflicts between the business requirements have to be solved. The specifications have to be formally documented, complete and signed-off.

Business processes describe the as-is and to-be processes of the organization. Relevant users and stakeholders have to participate in the identification and documentation of the processes. Furthermore, it is important that all relevant users and stakeholders understand the impact of the to-be situation and that the documentation is signed-off.

Internal control requirements describe the control requirements for the to-be situation. IT auditors have to be included in the identification process of these requirements and responsibility to manage the requirements has to be assigned.

Tool selection describes the selection process of new hardware and software. The process, agreement and criteria about the tools are formally documented. Further, it is important that the new hardware and

software is compatible with the current infrastructure and applications, and with the (to-be) Enterprise or IT Architecture.

Decision to customize or build the solution describes the criteria that the decision to develop new software or to configure and customize a standard software program, is based on. These criteria are the following: needs of the organization, reliability and stability risks, availability of knowledge about the new technology, IT strategy, planning and budget.

Functional and technical specification describes the aspects the functional and technical specifications are reviewed on. It is important that the specifications are discussed and understood by the organization and by the party that is going to implement the solution. The specifications have to be correct, complete and formally signed-off. Change management for the specification must be available.

Technical change management describes the change management for functional and technical specifications. When changes are required, the impact of these changes on scope, time, costs, risks and other requirements influences the decision to agree on the required change or not.

Configuration management describes which parties are responsible for the quality, change and configuration management.

Testing describes the parties, preparation and planning needed to test the proposed solution. It is important that the users participate in the testing process and that the test planning is a part of the project planning.

Implementation describes the knowledge and skills needed to implement the solution. Of course, it is important that specialists are available, but it is also important that the technique exists to implement the solution.

Besides the PRAM method, the IT auditors of KPMG use their own knowledge and experience when reviewing a project. Knowledge is gained through education and through interaction with other members. Experience is received from past project reviews.

9.2 Recommendations from Experts

As mentioned before, it is important to include stakeholders in a project. Three members of KPMG (each with an expertise in project reviewing) are included in this research through a brainstorm session. These members had requirements for the new method on the followings subjects:

- Ease of use
- Usefulness
- Risk mitigation
- Completeness

The method should be **easy in use**. This means that everyone should be able to work with the new method immediately without additional knowledge or experience.

The method should be **useful** and has to be applicable for every project. The new method should include many optional aspects and let the reviewer decide whether to include a specific aspect or not.

The new method should describe **potential risks** and how these risks can be minimized. As already seen in paragraph 4.3, many risks are possible.

The method should be **complete**, it should include both the RE process and the RE documentation. The current project review method of KPMG focuses on the RE process. The main reason for this is that it is difficult to go into detail about the content of the RE documentation. However, the RE documentation can provide relevant information (like choices and decisions) about the RE process. Therefore, the new method should contain elements to assess the quality of the RE documentation.

10. Use of the Current Situation

The current review approach of KPMG contains 10 subjects relevant for the RE process, each with several relevant aspects. These aspects will be used as an inspiration for the new method.

Furthermore, three experts have given requirements for the new method. These requirements are summarized in Figure 18.

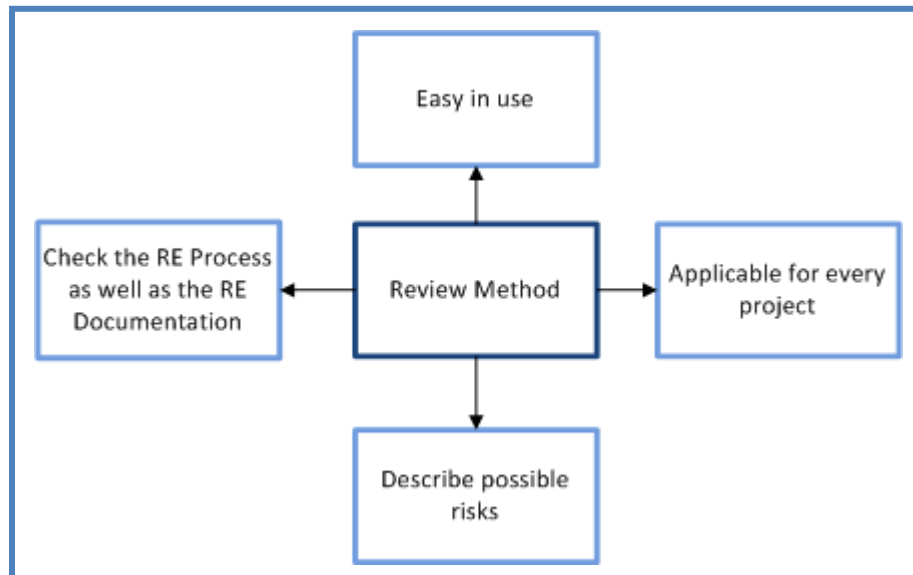


Figure 18. Summary of current situation

The requirements will be processed in the new method by describing possible risks and by adding special aspects to check the RE process and special aspects to check the RE documentation. The new method will be validated by six members to test the ease of use and usefulness of the method.

This summary, in combination with the result of Part II, is used to develop a first version of the RE review method. This first version, the proposed method, can be found in chapter 11.

11. Proposed Method

This chapter describes the proposed method. The method is based on the summary in chapter 7 and the summary in chapter 10. The proposed method can be found in Appendix A.

The proposed method exists of four steps, as can be seen in Figure 19.

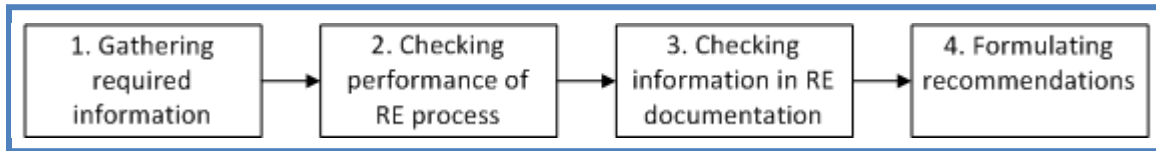


Figure 19. Steps in the proposed method

The first step is to gather required information. To gather required information, one or more of the information identification and elicitation techniques can be used. More about which specific information needs to be gathered can be found in method itself.

The second step is to check the performance of the RE process. It is necessary to check the performance of the RE process before checking the information in the RE documentation, because the performance of the RE process gives relevant information about the presence of several aspects in the RE documentation.

The performance of the RE process will be assessed with the first checklist. The reason to choose a checklist is that checklists are easy in use, easy to understand and easy to draw conclusions from. In the checklist, six risks are formulated together with a list of aspects that can minimize the specific risk. Reviewers can register the score of the specific aspects in the checklist using the following symbols:

- ✓ aspect is present
- ✗ aspect should be present, but is not present
- aspect is not applicable in this project

Additionally, space is available to add comments.

The applicability of an aspect in the checklist is open for interpretation by the reviewer. In this way, the members of KPMG are supported but not restricted by the checklist, as they can still apply their personal knowledge and experience to each individual project when they consider it necessary.

The third step is to check the information in the RE documentation. The information will be assessed with the second checklist. The use of the checklist is similar to that of the first checklist.

The fourth step is to formulate recommendations. Based on the results of step 2 and 3, the following questions can be answered and the answers can be used to draw conclusions:

- What aspects do come back in the process?
- What aspects should have come back in the process, but were not present?
- What aspects do come back in the documentation?
- What aspects should come back in the documentation but were not present?

- What are potential risks when looking at the above aspects?

Based on the conclusions, recommendations can be formulated. The following questions can be used to formulate these recommendations:

- What can be done to improve the RE process?
- What can be done to improve the RE documentation?

The proposed method is improved and validated in the rest of the research. Part IV describes into more detail how this is done and which real-life cases are used for this.

Part IV: Practical Insights

In Part IV, the following subject are discussed consecutively: the research method, improvements to the method and validation of the method. The research method contains a description of the real-life cases that are used to test and validate the proposed method, a description of how data is collected and a description of how data is analyzed. Improvements to the method contains the results and recommendations of the first two cases (A and B) and information about the improvements made to the proposed method. Validation of the method contains the results and recommendations of the other six cases (C to H) and information about the changes made to the improved method.

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12. Research Method

This chapter contains information about the research method. The following aspects are described consecutively: the eight cases, the data collection approach and the data analysis approach.

12.1 Description of the Cases

In this research, two cases are used to test and improve the proposed method and six other cases are used to validate the improved method. All eight cases are described briefly in this paragraph.

Case A is about the digitalization of the audit process of a large global financial audit organization. Before the start of the project, the organization performed all audits on paper, resulting in an inefficient process and a disadvantage compared to its competitors. Therefore, the goal of the project was to build an application that would do the following:

- Increase the efficiency of the processes
- Increase the quality of the processes
- Increase competitiveness

The project was started in 2006 and the product has been in use since the summer of 2010. This means that the product is in use for half a year. In the first few months, five updates of the product have been released. This project is reviewed twice by KPMG: during the final stage of the RE process and after the RE process. Based on the first review of the project, the RE process was changed. The second review was about the changed RE process.

Case B is about the decision for and the implementation of an ERP system in a small Dutch organization. Before the start of the project, the IT-system did not support all processes in the organization. Several related processes were performed separately, resulting in an inefficient process and decision-making based on incomplete information. Therefore, the goal of the project was to choose and implement an ERP system that would do the following:

- Support all processes in the organization
- Increase the efficiency of the processes
- Increase the availability and correctness of information

The project was started in 2009 and after one and a half year, the product was completely implemented. KPMG has guided the organization in their decision for a specific ERP system. Moreover, KPMG has helped them understand their business models and business processes and has given them recommendations on how to make the decision for an ERP system. After the decision for an ERP system was made, KPMG has guided the organization during the implementation in order to make sure that business processes and ERP system would be in alignment at the end of the project. The review has taken place after finishing the RE process.

Case C is about the decision for and implementation of a new web-application for a large global publishing organization. Before the start of the project, the organization contained several independent

IT-departments, resulting in an inefficient IT management process and an absence of uniformity towards customers. Therefore, the goal of the project was to build a web-application that would do the following:

- Decrease the number of IT departments
- Increase the efficiency of the IT processes
- Increase uniformity towards customers

The project was started a few years ago. At the time of writing, the solution is tested through the use of a pilot. KPMG has guided the organization during the RE process and has performed several reviews in order to make sure that the right application is implemented. KPMG is still involved in the project.

Case D is about the digitalization and automation of the information processing process in a small Dutch organization. Before the start of the project, all information had to be processed by employees, resulting in an inefficient process and a high probability of mistakes. Therefore, the goal of the project was to choose and implement an application that would do the following:

- Increase the efficiency of the process
- Increase the quality of the process
- Develop standard formats for incoming information

The project was started a few years ago and, at the moment of writing, the project is around the end of the RE process. KPMG has guided the organization during the RE process by their decision for a software system and reviewed the RE process up to this point.

Case E is about the decision for and implementation of a new application for a large European provider for electronic manufacturing services. Before the start of the project, the organization had an old application that was no longer supported by the supplier and because of that it was not been updated for a while. Therefore, the goal of the project was to choose and implement an ERP system that would do the following:

- Replace the old application
- Support a few extra functions
- Increase the efficiency of the process

The project was started in 2004. After two years, the organization came to the conclusion that the project was failing and they stopped the project. A few years later, they decide to start the project over again, with the same requirements and the same supplier. This time, they divided the RE process in two phases: one to copy the old system and one two improve the system with new functions. About a year ago, in the begin of 2010, this project is reviewed by KPMG. This is done just before the pilot. The reason they asked KPMG to perform the review is because the project took longer than expected and they wanted to know the reason for this and how they could speed up the process.

Case F is about the decision for and implementation of a new application for a large Dutch food supply organization. Before the start of the project, the organization had an old application that needed a lot of

customization and was not flexible. Therefore, the goal of the project was to choose and implement an application that would do the following:

- Replace the old system
- Support all processes in the organization
- Increase the quality of the ordering process for customers

The project was started in 2008 and, at this moment, the project is around the end of the RE process. The decision has been made to implement a three-application landscape, among others an ERP-system. These systems have to work together in the future to support the complete business processes. They divided the RE process in two phases, resulting in an in-between delivery. A lot of RE documentation is available for this project. In January 2011, this project is reviewed by KPMG. This is done at the end of the RE process in order to assess this part of the project. At the moment of writing, KPMG is still involved in the project.

Case G is about the specification and implementation of an application for twelve Dutch organization, supplying of the same product. Before the start of the project, the organizations shared information by sending e-mails. In most cases around the ten e-mails are send about one case. This information sharing can be done faster by an application with a corresponding database. Therefore, the goal of the project was to specify and implement an application that would do the following:

- Share information between the organizations
- Increase the efficiency of the processes between the organizations
- Increase the quality of the service provided to customers

The project was started one and a half year ago. At the moment of writing, the application is ready to be implemented in one of the organizations. When this implementation has succeeded, the application will be extended for implementation in the other organizations. KPMG has guided the organization during the RE process and has performed several reviews.

Case H is about the specification and implementation of an application for a Dutch government organization. Before the start of the project, the organization had an old application that had to be renewed because of new governmental regulations. Therefore, the goal of the project was to build and implement an application that would do the following:

- Replace the old system
- Support a few extra functions
- Increase the efficiency of the processes

The project was started approximately three years ago. At the beginning, an external party was hired to build and implement the solution. However, after a few months the organization came to the conclusion that the project has failed. At that moment, they decided to build and implement the solution themselves. The organization hired a team with specialists to do this. From that moment, the project was based on agile development. At the moment of writing, the application is in use for half a year. KPMG has

helped the organization by assessing the usefulness of the organization's development method. The review has taken place half a year for implementation. At the moment of the review, a part of the application was already developed.

The case descriptions are summarized in Figure 20.

Case ID	Product	Scope Project	Role KPMG	Scope Review
A	Custom software development	Large global organization	Review	Complete RE process
B	Off-the-shelf software configuration and customization	Small Dutch organization	Guidance and review	Complete RE process
C	Custom software development	Large global organization	Guidance and review	Individual phases of the RE process
D	Off-the-shelf software configuration and customization	Small Dutch organization	Guidance and review	RE process up to but not including the configuration and customization
E	Off-the-shelf software configuration and customization	Large European organization	Review	RE process except pilot
F	Off-the-shelf software configuration and customization	Large Dutch organization	Review	Complete RE process
G	Custom software development	Large Dutch organization	Guidance and review	Individual phases of the RE process
H	Custom software development	Small Dutch organization	Review	Complete RE process (part of the software is already developed)

Figure 20. Summary of case descriptions

12.2. Data Collection

This paragraph contains information about the data collection process. There are two data collection phases: one in the test phase and one in the validation phase. For the test phase, cases A and B are used. For the validation phase, cases C to H are used.

Cases A and B are used to test the proposed method. The goal of this testing is to improve the proposed method by observing and analyzing its application to a real world example. Data about these cases was collected from KPMG members who were actively involved with these cases. The following information was provided by them:

- Documentation KPMG performed their review on
- Extra information KPMG has received from stakeholders before the review
- Review documentation written by KPMG

Cases C to H are used to validate the improved method. The goal of this validation is to improve the improve method. Data about these cases was retrieved from the members, who have reviewed the

specific cases in the past. To collect the data, the members of KPMG are asked to perform three steps. These steps are shown in Figure 21.

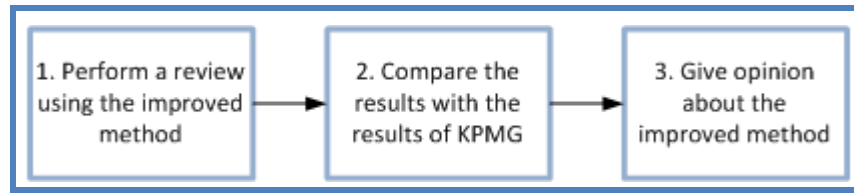


Figure 21. Steps the members are asked to perform during the validation

The first step is that the member performs a review to the specific project using the improved method. For this step, the improved method is given to the member of KPMG. The member is asked to use the method without additional guidance.

The second step is that the member compares the results of the improved method with the results of the review performed by KPMG. Comparison is done to check if differences exist between the results. Possible differences between the results are discussed.

The third step is that the member gives his or her opinion about the improved method. The members are asked to give their opinion about the completeness, usefulness and ease of use of the method. The following questions are asked to retrieve a complete opinion:

- What aspects do you miss in the method? Why?
- What aspects should be changed? Why?
- Do you think that the method is applicable in other projects?
- Do you think members of KPMG should use the method in the future?

12.3 Data Analysis

After all data is collected, it has to be analyzed. This paragraph described the way in which the data is analyzed. There are two data analysis phases: one in the test phase and one in the validation phase. For the test phase, cases A and B are used. For the validation phase, cases C to H are used.

In the analysis of the data of case A and B, five steps are performed. The steps are shown in Figure 22.

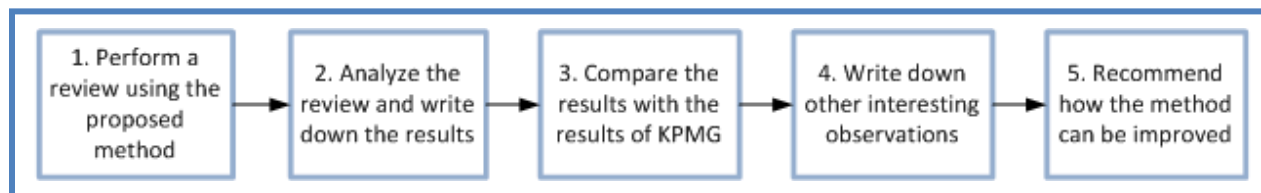


Figure 22. Steps in the data analysis of case A and B

The first step is to perform a review using the proposed method. In the review all elements of the checklist are checked for presence in the RE process or in the RE documentation.

The second step is to analyze the review and write down the results.

The third step is to compare the results with the results of the review performed by KPMG. Comparison is done to check if differences exist between the results. Possible differences between the results are discussed.

The fourth step is to write down other interesting observations. These are observations that do not arise from one of the previous steps but are still relevant to the specific case or the RE process in general.

The fifth step is to decide how the method can be improved and to change the method accordingly. Deciding how the method can be improved is done through the combined results of the steps above. Based on the decisions, the method will be improved.

The analysis and results of the testing phase can be found in chapter 13.

In the analysis of the data of case C to H, three steps are performed. These steps are shown in Figure 23.

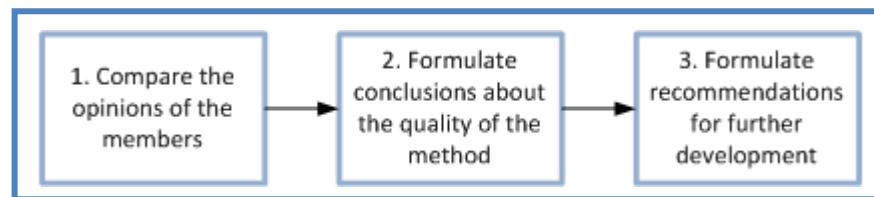


Figure 23. Steps in the data analysis of case C to H

The first step is to compare the opinions of the members. Comparison is done to check if each member has the same opinion about the method. Differences between the opinions are discussed.

The second step is to formulate conclusions about the quality of the method. These conclusions are based on the opinions of the members and they are drawn about the completeness, consistency and usefulness of the method.

The third step is to formulate recommendations for further development of the method. These recommendations are based on the conclusion from step 2.

The analysis of the validation can be found in chapter 14. The conclusions can be found in chapter 15.

13. Improvements to the Method

In this chapter, the analyses of the data from case A and case B are discussed. Based on the results of the analyses, recommendations to the proposed method are given. Subsequently, the improved method is described.

13.1 Results Case A

The proposed method is used to review case A. The results of this review and the results of the first review performed by KPMG are summarized in Figure 24.

Results review case A
Results review proposed method <ol style="list-style-type: none">1. The scope of the project is clear2. A list with approximately 1300 business requirements is documented3. Before the first review, no users were included and the proposed solution is not tested on exceptions and missing requirements and no pilot is performed4. The documentation is incomplete and lacks: a realistic planning, a cost specification, scope information, a problem description, a goal description, constraint information, a risk specification, a stakeholder specification, a requirements prioritization, a list with functional and non-functional requirements5. No agreements of relevant stakeholders are available
Results first review KPMG <ol style="list-style-type: none">1. No clear alignment, in terms of scope, budget, risk profile and deliverables, between the business case drivers and the project is present2. No effective governance via a program and project organization is present3. No project director is appointed4. The role and responsibility of the line organization is ambiguous5. A risk on ineffective functional design because of the unclarity on the new audit concepts and the number of functional requirements workshops is present6. The requirements specification phase should be adjusted to better reflect the incremental/iterative approach: validations of the new concepts by real-life prototypes can realize this

Figure 24. Results review case A

The aforementioned aspects are checked for occurrence in their respective counterparts. For each result of the KPMG review, its relation to the proposed method is described and explained. Results from the proposed method that do not follow from the KPMG method are not further discussed, as the focus lies on improving the current method and such results are a natural by-product of improving the method.

No clear alignment, in terms of scope, budget, risk profile and deliverables, between the business case drivers and the project is present. The proposed method does check on the availability, correctness and completeness of the scope, budget, risk profile and deliverables of the project, but not on the alignment with the business case drivers. We expect that this discrepancy is due to the fact that theory focuses on the RE process as a standalone process instead of as a process within a business context.

No effective governance via a program and project organization is present. The proposed method does not check this aspect. Moreover, the proposed method does not say anything about delegation of responsibilities with regard to deliverables. This is also reflected in the next two aspects.

No project director is appointed. As mentioned, the proposed method does not yet check on responsibilities.

The role and responsibility of the line organization is ambiguous. As mentioned, the proposed method does not yet check on responsibilities. However, it does check that all relevant stakeholders are included and that all relevant stakeholders are specified.

A risk on ineffective functional design because of the unclarity on the new audit concepts and the number of functional requirements workshops is present. The proposed method does check that the goals and solution of the project are described and that the planning is realistic and contains the right activities, but it does not link the result to the risk on ineffective functional design. This is because the ineffective functional design is not considered a risk in the problem bundle.

The requirements specification phase should be adjusted to better reflect the incremental/iterative approach: validations of the new concepts by real-life prototypes can realize this. The proposed method does check that the proposed solution is tested on specific situations, exceptions and missing requirements, is tested in practice and that, at the end, an agreement of the requirements specification is given by relevant stakeholders. The results of the two reviews are similar as can be seen in result 3.

From the interview with the member of KPMG, it became clear that 1300 business requirements are formulated. This will probably result in thousands of functional requirements. Therefore, a complete list and specification is not clarifying.

Besides the review and the comparison of the results with the results of KPMG, two observations are made.

- The organization has made well-informed decisions
- The RE documentation is not only incomplete, but is also unstructured

From the interview with the member of KPMG, it became clear that the organization has made well-informed decisions. They have thought well about what they want to obtain, why they want to obtain this and how they want to obtain this. An example of a well-informed decision they have made is to minimize the customization needed for each country and to extend the basic features of the product. However, the decision process was not reflected within the documentation, which means that these decisions are likely to be irretrievable in follow-up projects.

The RE documentation is not only incomplete, but is also unstructured. Without the extra information provided by KPMG it would not be clear why the project is performed, why specific choices are made and what actions have been performed and in which order. Furthermore, the information is not bundled in one document but spread over several documents.

13.2 Results Case B

The proposed method is used to review case B. Unfortunately, the RE documentation was unavailable for this research. Therefore, the proposed method is only used to review the RE process. The results of this review and the results of the review performed by KPMG are summarized in Figure 25.

Results review case B
Results review proposed method <ol style="list-style-type: none">1. The scope of the project is clear2. Relevant stakeholders have agreed on the planning, the cost specification and the chosen ERP system3. No users were included during the RE process4. The proposed solution is not tested in practice and, because of that, the influence of the solution was not clear at the moment of the decision for the ERP system
Results review KPMG <ol style="list-style-type: none">1. A smaller ERP-system could have been chosen, because many modules are not used and it would have been cheaper to buy and to maintain2. More attention should have been paid to the consequences of the chosen ERP-system, they did not realize the amount of changes that had to be made in the business processes3. The implementation of an ERP-system is chosen to support business processes, within this choice no attention is paid to the influence on users

Figure 25. Results review case B

The aforementioned aspects are checked for occurrence in their respective counterparts. For each result of the KPMG review, its relation to the proposed method is described and explained. Results from the proposed method that do not follow from the KPMG method are not further discussed, as the focus lies on improving the current method and such results are a natural by-product of improving the method.

A smaller ERP-system could have been chosen, because many modules are not used and it would have been cheaper to buy and to maintain. The proposed method does not check if well-considered choices are made. However, the proposed method does check that all relevant stakeholders have agreed on the decision for the chosen ERP system. From the interview with the member of KPMG, it became clear that the organization did make a deliberate decision when they chose the ERP system; the decision is based on the costs estimated for acquisition.

More attention should have been paid to the consequences of the chosen ERP-system; they did not realize the amount of changes that had to be made in the business processes. The proposed method does, to some extent, check on this aspect; the results of the proposed method show us that the influence of the solution was not clear at the moment of the decision. However, the proposed method does not check specifically on the influence on the business processes.

The implementation of an ERP-system is chosen to support business processes, within this choice no attention is paid to the influence on users. The proposed method does not check on this aspect. However, the results of the proposed method show us that no users were included during the RE process.

Besides the review and the comparison of the results with the results of KPMG, one observation is made. From the interview with the member of KPMG, it became clear that the planning and cost specification proved to be unrealistic. The project took more than two times the expected time and cost a third more than expected. Knowing that they based the final decision for the ERP system on the costs of the acquisition, they maybe would have chosen another ERP system if they had been aware of the real costs.

13.3 Recommendations

In Figure 26, the most important observations of cases A and B, are summarized.

Observations of case A and B	Based on case
RE process checklist	
1. Clarity about the roles and responsibilities of stakeholders is important	A
2. A project director should have been appointed	A
3. Alignment between chosen solution and business model is important	A
4. Well-informed decisions should be made on all relevant aspects	A and B
5. Attention should be paid to the influence of the product on the business processes	B
6. Attention should be paid to the influence of the product on users	B
RE documentation checklist	
7. A list with requirements is not useful if the list becomes too large	A

Figure 26. Observations of case A and B

Clarity about the roles and responsibilities of stakeholders is important in order to reach a well-managed project. When roles and responsibilities are not clear, people do not know what they are supposed to do, resulting in the possibility that time is spend on the wrong activities.

A project director should have been appointed to have one person in charge that manages the complete project and has the responsibility that the project succeeds.

Alignment between chosen solution and business model is important. The project should be in line with the business model in order to gain profit from it.

Well-informed decisions should be made on all relevant aspects. Several aspects should play a role in documentation of the decisions: the actual decisions that are made, their explanations and impact, and the list of open questions.

Attention should be paid to the influence of the product on the business processes. Of course, the product is often the element that is adjusted to the organization and the business processes it will be used for, but, on some aspects, it may be impossible to adjust the product. In that case, the business processes have to be adjusted to the product. Therefore, it is important to pay attention to the influence of the product on the business processes.

Attention should be paid to the influence of the product on the futures users. The users are the parties that have to work with the product in the future and whose working activities are going to change.

Therefore, it is not only important that users are included in the project, but also that the influence the project has on the users is paid attention to.

A list with requirements is not useful if the list becomes large. It is important that all stakeholders understand the whole set of requirements, therefore, other techniques for documenting the requirements can be used. An example of such a technique is prototyping.

13.4 Improved Method

Based on the recommendations from cases A and B, the proposed method is improved on the aspects given in Figure 27.

Improvements to the proposed method
Changes in the RE process checklist <ol style="list-style-type: none">1. An items about the roles and responsibilities of stakeholders is added2. An item about the presence of a project director is added3. An item about the alignment between the project and the business model is added4. An item about decision making is added for all relevant aspects5. An items about the attention paid to the influence of the product on the business processes is added6. An item about the attention paid to the influence of the product on users is added
Changes in the RE documentation checklist <ol style="list-style-type: none">7. Items about the lists of requirements are deleted and two new items are added: one about the functional requirements specification and one about the non-functional requirements specification

Figure 27. Improvements made to the proposed method

The improved method can be found in Appendix B. The improved method is validated in this research and the results of this validation can be found in chapter 14.

14. Validation of the Method

In this chapter the analysis of the data from case C to H are discussed in the form of remarks with regard to the completeness of the method and to the usefulness of the method.

14.1 Results

The method is validated by six members of KPMG. The complete list with recommendations per case can be found in Appendix D. In this paragraph, the completeness, usefulness and ease of use of the method are discussed briefly.

Concerning the completeness of the method, the members recommended to add several aspects. The five most important aspects are the following:

- A close cooperation between architect, IT and users should take place
- All stakeholders should have a clear understanding of the to-be situation
- A clear sign-off procedure should take place
- When more than one deliverable is planned, a project can exist of different phases
- High-level requirements should be documented

A close cooperation between architect, IT and users should take place. The improved method already checks that relevant stakeholders participate actively during specific elements of the RE process. The added value of this aspect is that more moments are included within this formulation. A close cooperation is especially important during the testing phase in an iterative process.

All stakeholders should have a clear understanding of the to-be situation. The improved method already checks that attention is paid to the influence of the proposed solution on the business process and on the users; the improved method already pays attention to the influence of the solution on the to-be situation. The added value of the clear understanding of the to-be situation by all stakeholders is that, before the sign-off procedure, all stakeholders know the impact of the chosen solution. The influence of the to-be situation can be communicated to the stakeholders by, for example, a workshop or a presentation.

A clear sign-off procedure should take place. This is important in order to make sure that no discussion about the requirements specification can arise at a later moment. The improved method already pays attention to the agreement of relevant stakeholders to specific elements of the RE process. The added value of the sign-off procedure is the formality of the agreement. In complex projects, with a large budget and an extensive planning, this is practically mandatory.

When more than one deliverable is planned, a project can exist of different phases. It is important that for each phase a separate planning, budget and set of goals are described. Furthermore, the deliverable of a phase should be independent of the deliverables of the next phases. The improved method does not distinguish the possibility of different phases in a project. Therefore, it is good that this recommendation is made.

High-level requirements should be documented. The improved method does not check that high-level requirements are described. High-level requirements can help to retrieve a basic view of the solution, to focus on the right direction and to check if the goal of the project will be obtained with the proposed requirements. High-level requirements are especially important in an iterative process, because not all requirements are specified in detail in those processes.

Concerning the usefulness and ease of use of the method, the six members of KPMG, that have performed the validation, have declared that with the changes they have recommended, the method is complete, applicable and easy to use. The method is complete and easy enough for new members that have never reviewed the RE process before, and it can be used as a reminder for members that have reviewed the RE process many times before. Furthermore, the method can, according to these six members, be used for many projects.

14.2 Recommendations

In Figure 28, the most important observations of cases C to H, are summarized on three main subjects: the method in general, the RE process checklist and the RE documentation checklist.

Observations	Based on case
Method in general	
1. In step 1 of the method, the aspects should be explained in more detail	D
2. The classification in risks is good, but risk three to six do overlap on some aspects	F
3. It is not necessary that the topics in both checklists matches	F
4. In step 3 of the method, no distinction is made between process aspects and content aspects in the RE documentation	D
5. In step 4 of the method, no question is asked about the reasons behind the conclusion and recommendations	F
RE process checklist	
6. The checklist does not check that all stakeholders have a clear understanding of the to-be situation (through workshops/presentation etc.)	C and F
7. The checklist does not check if the project is divided into different phases and if these phases are specified correctly	C, E and F
8. The checklist does not check on a clear sign-off procedure	C and F
9. The checklist does not check that stakeholders have evaluated the correctness of requirements (through workshops etc.)	C
10. The checklist does not check on close cooperation between architect, IT and users, this is especially important during the testing phase	C and H
11. The checklist does not check that, in case of delivery of the product in different phases, the business process are still performing as they should do	F
12. The checklist does check on attention paid to cultural differences, 'local differences' may be a better formulation	D and F
RE documentation checklist	
13. Concerning the realistic costs specification, this can be checked by looking at, for example, the invoices	G

14. The checklist does not check that high-level requirements are documented	C, D and G
15. The checklist does not check that process flows are documented	C
16. Concerning the non-functional requirements, privacy aspects and governmental regulation are important to check	G
17. The checklist does not check that documentation is available concerning choices and decisions that are made	C
18. The checklist does not check on the clearness of diagrams and tables	C
19. The checklist does not check that the level of detail in the requirements specification matches	F
20. The checklist does not check that it is clear which documentation is available	F
21. Concerning unambiguousness of information, this can be done by adding a glossary to the RE documentation	F
22. Concerning consistent information, this means for content, document templates etc.	F
23. Concerning traceability of information, 'the reasons behind requirements and decisions are given' may be a better formulation	E and F
24. It is necessary that the checklist checks the quality of the information in the RE documentation	F
25. It is unnecessary that the checklist checks the quality of the information in the RE documentation	D

Figure 28. Observations based on case C to H

Two members have conflicting recommendation. It concerns **recommendations 24 and 25**: whether it is necessary or not to check the quality of the information in the RE documentation. According to the member who reviewed case F, the assessment of the quality of the information in the RE documentation is necessary because documentation is available. According to the member who reviewed case D, the assessment of the quality of the information in the RE documentation is unnecessary because no or minimal documentation is available in most projects. Apparently, the conflict is about the presence of RE documentation in projects. During this project, we have seen that in six out of eight projects, RE documentation was, at least to some extent, present. Therefore, we join the opinion of the member who reviewed case F and conclude that it is necessary that the method gives the possibility to check the quality of the information in the RE documentation.

14.3 Final Method

Based on the recommendations from cases C to H, the improved method is changed. The changes are described in Figure 29 and the final method can be found in Appendix C.

Changes to the improved method
Changes in the method <ol style="list-style-type: none"> 1. The aspects in step 1 of the method are explained in more detail 2. In step 2 and 3, risk three to six are combined and are changed into the risk 'Product does not satisfy wishes of stakeholders' 3. In step 2 the 'new' risk three is divided into the first two steps of the RE process as described by Kotonya and Sommerville (1997) 4. In step 3 the 'new' risk three is divided into the process aspects, the content aspects and the quality aspects of the checklist

5. In step 4 of the method, a question about the explanation behind the conclusion and the recommendations is added

Changes in the RE process checklist

6. An item about a clear understanding of the to-be situation by all stakeholders (through workshops/presentation etc.) is added
7. An item about different phases of a project and about a correct specification of each of these phases is added
8. An item about a clear sign-off procedure is added
9. An item about the evaluation of the correctness of requirements by stakeholders (through workshops etc.) is added
10. An item about a close cooperation between architect, IT and users (especially during the validation and testing) is added
11. An item about the performance of the business processes, in case of delivery of the product in different phases, is added
12. The item about attention paid to cultural differences is changed into 'attention is paid to local differences'

Changes in the RE documentation checklist

13. To the item about the realistic costs specification is added that this can be checked by looking at invoices
14. An item about the documentation of high-level requirements is added
15. An item about the documentation of process flows is added
16. To the item about the non-functional requirements is added that the checklist should check on privacy aspects and governmental regulation
17. An item about the documentation of choices and decisions is added
18. An item about the clearness of diagrams and tables is added
19. An item about the match in level of detail of the requirements specification is added
20. An item about the availability of documentation is added
21. To the item about that information is unambiguous is added that this can be done by adding a glossary to the RE documentation
22. To the item about the consistency of the checklist is added that this means for content as well as for the document template
23. The item about the traceability of information is changed into 'the sources and/or reasons behind requirements and decisions are given'

Figure 29. Changes made to the improved method

Part V: Conclusions and Recommendations

In Part V, the conclusions and recommendations are given and discussed. This part starts with an answer to the research question and an explanation of this answer, followed by suggestions for future research. At the end, recommendations are given.

Content of Part V:

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15. Conclusion

This chapter uses the results of Part II to IV to reach a conclusion. This will be done by answering the research question, giving an explanation to this answer and providing future research possibilities.

15.1 Answer to the Research Question

The research question was as follows:

- Which aspects can be used to assess the quality of the RE process for complex software development projects?

The answer to the research question is that the following three main aspects can be used to assess the quality: planning, budget and the quality of the solution. For each of these three aspects, stakeholders will have expectations they attach great value to. Therefore, it is important that these expectations are met and that the chance of not meeting is minimized. This can be done by assessing the performance of the RE process, as well as the information in the RE documentation, on these three aspects. The most important elements for the RE process and RE documentation concerning the planning, budget and quality of the solution are described in Figure 30.

Main Aspects	RE Process	RE Documentation
Planning	The scope of the project has to be clear to all stakeholders and the roles and responsibilities of stakeholders have to be clearly communicated	The planning has to be realistic and has to contain the right activities
Budget	An agreement has to be reached about the cost specification	The cost specification has to be realistic and possible risks have to be described
Quality of the Solution	<i>Elicitation</i> – needs, opinions and expectations have to be discussed with relevant stakeholders <i>Analysis</i> – the solution has to be in alignment with the business model and attention has to be paid to the influence of the solution in the business processes <i>Negotiation</i> – Relevant stakeholders have to agree on the requirements specification and a clear sign-off procedure has to take place	<i>Process description</i> – All choices, decisions and agreements have to be described <i>Documentation content</i> – All requirements have to be specified on a high-level as well as on a detailed-level <i>Documentation quality</i> – All information in the documentation must be correct, complete, consistent and unambiguous

Figure 30. Most important aspects concerning budget, planning and quality of the solution

The goal of this research was to develop a method that can be used to assess the quality of the RE process. This goal is reached. A complete and useful method is developed, with three important benefits in comparison with KPMG's current review method:

- The method is specifically focused on assessing the quality of the RE process

- The method contains aspects that are absent in KPMG's current method
- The method provides, where applicable, examples of several aspects to facilitate the judgment on these aspects

One problem of the current method was that the method was not applicable for use in an iterative project. Although this problem is not completely solved, it has been mitigated. In the developed method, attention is paid to the aspects that are important in an iterative process.

The answer to the research question is elucidated in the following paragraph.

15.2 Explanation of the Answer

The answer to the research question is that three aspects are important when assessing the quality of the RE process: planning, budget and the quality of the solution. The aspects are shown in Figure 31. Even though all aspects are important, organizations should focus on one of the aspects. All organizations want a project to deliver a high-quality solution within a short time and a low budget. However, in a complex project, a low budget in combination with a short time, often does not result in a high-quality solution. Therefore, expectations should be adjusted, according to the choice of focus. Of course, this does not change anything about the necessity that the adjusted expectations are met.

However, not only the performance of the RE process, but also the RE documentation is important, because the RE documentation can be seen as the deliverable of the RE process. The current review method of KPMG focuses only on the evaluation of the RE process and ignores the evaluation of the RE documentation.

For each of the main aspects, the elements main elements concerning the RE process and RE documentation are discussed.

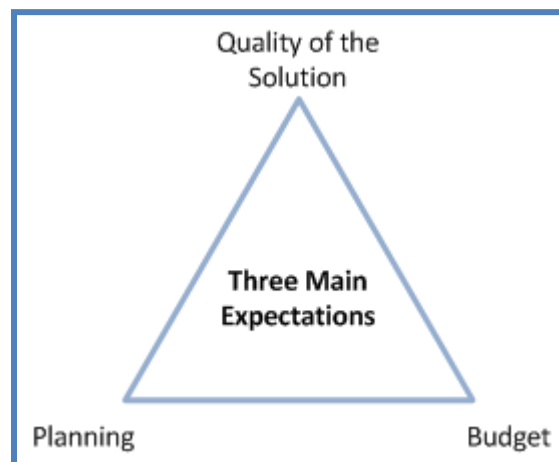


Figure 31. The three main aspects that can be used to assess the quality of the RE process

Concerning the planning, it is important that the scope of the project is clear to all stakeholders, that the roles and responsibilities of stakeholders are communicated clearly and that the planning is realistic and contains the right activities. These four aspects together will minimize the chance of exceeding the planning. When the planning is not realistic, it is not possible to succeed in the estimated time. When the

scope of the project is not clear to all stakeholders or when the wrong activities are planned, the planning may exceed due to the necessity of repetition or changes during the project. When the roles and responsibilities of stakeholders are not communicated clearly, stakeholders may not know what they have to do and important activities might be forgotten or performed in a wrong way. This may also result in exceeding the planning.

Concerning the budget, it is important that the cost specification is realistic, that an agreement is reached about the cost specification and that potential risks are described. The three aspects together will minimize the chance on exceeding the budget. When the cost specification is not realistic, it may be impossible to succeed within the budget estimated. When no formal agreement is reached about the cost specification, it is unknown if all stakeholders agree on the budget and problems concerning the payments of the costs can arise during or after completion of the project. When possible risks are not described, the mitigation and possible influences of risks are not included in the cost specification. In case of unexpected events, this may result in exceeding the budget.

Concerning the quality of the solution, three aspects are important in the RE process: requirements elicitation, requirements analysis and requirements negotiation. For requirements elicitation, it is important that the needs, opinions and expectations of stakeholders are discussed. This is important in order to deliver a product that satisfies the wishes of the stakeholders. For requirements analysis, it is important that the solution is in alignment with the business model and that attention is paid to the influence of the solution on the business processes. This is important in order to develop a product that contributes to the business goals and to make sure the influence on current processes is known. For requirements negotiation, it is important that all relevant stakeholders have agreed on the requirements specification and that a clear sign-off procedure has taken place. This is important in order to make sure all stakeholders know the financial consequences of the project and that no discussion can arise at a later moment about the requirements specification.

Concerning the quality of the solution, three steps are important in the RE documentation: process description, content of the documentation and quality of the documentation. For the process description, it is important that all choices, decisions and agreements are described, so they may be referenced in case of an argument. For the content of the documentation, it is important that requirements are specified on a high-level as well as on a detailed-level. The high-level specification can be used to check if the goal of the project is reached with the proposed requirements, the detailed-level specification can be used to implement the proposed solution. For the quality of the documentation, information should be correct, complete, consistent and unambiguous, so that all stakeholders have the same, correct and understandable information, and to make sure that parties that are unfamiliar to the project can use the documentation to find and understand all relevant information about the project.

The goal of this research is reached: a method is developed that can be used to assess the quality of the RE process. The developed method has three important benefits in comparison with KPMG's current review method:

- The method is specifically focused on assessing the quality of the RE process

- The method contains aspects that are absent in KPMG's current method
- The method provides, where applicable, examples of several aspects to facilitate the judgment on these aspects

The method is specifically focused on assessing the quality of the RE process. The current method can be used to review a complete project. The developed method is focused on the RE process only and therefore better suitable to review the RE process.

The method contains aspects that are absent in KPMG's current method. The current method is incomplete; it contains only a few high-level aspects and important aspects are missing. The missing aspects are included in the developed method, making this method more complete than the current method.

The method provides, where applicable, examples of several aspects. These examples can make it easier for the reviewer to judge if the specific aspect is performed or present.

All aspects that came up during the brainstorm sessions with members of KPMG are processed into the developed method. The method describes the RE process as well as the RE documentation; it makes use of the steps, techniques and main risks in the RE process and attention is paid to the quality and content of the RE documentation.

One problem of the current method is that the method was not applicable for use in an iterative project. This problem is not completely solved with the developed method, but it has been mitigated. In the developed method, attention is paid to the aspects that are important in an iterative process. This concerns the following aspects:

- A close and regular cooperation between architect, IT and users
- Validation for specific situations and exceptions
- High-level requirements

A close cooperation between architect, IT and users is important in an iterative process. Users should participate during the complete project in order to develop a product that satisfies the wishes of the future users. Users may also be the ones that know how specific processes are performed in the organization and can possibly provide relevant information about these processes to the architect.

Validation and testing of the proposed solution is also important in an iterative process, because the results can be used to indicate if the RE process has been finished or if a new iteration is needed.

In an iterative process, it is important that high-level requirements are described, because, although detailed requirements may change between iterations, the high-level requirements tend to remain unchanged. High-level requirements can be used to retrieve a basic view of the solution, to focus on the right direction and to check if the goal of the project is reached with the proposed solution.

The six members of KPMG that have performed the validation of the developed method, have declared that the developed method is complete, useful and easy to use. According to them, the method can be

used by everyone that has to perform a review of the RE process; the method is complete and easy enough for new members that have never reviewed the RE process before, and it can be used as a reminder for members that have reviewed the RE process many times before.

15.3 Future Research

Two interesting observations are made during the research:

1. The majority of the projects do not have a RE documentation
2. Not all organizations perceive the RE process to be essential

The majority of the projects do not have an RE documentation. However, according to the theory, the RE documentation is very important. The development of documentation is one of the main steps in the spiral model described by Kotonya and Sommerville (1997). According several experts, The majority of the organizations do not have an complete RE documentation, because the development of the RE documentation is time-expensive and the added value is limited. Because of this mismatch, we advise to perform a research on the following subjects:

1. The incentives of organizations to neglect development of RE documentation
2. The necessity of documentation in the context of current software development projects
3. Procedures to encourage organizations to develop RE documentation

The results of the first two subjects can be used to check if the mismatch between theory and practice stems from outdated assumptions in theory or from incorrect assumptions in practice. Based on these results, conclusions can be drawn about the necessity of organizations to pay attention to the RE documentation. If this necessity exists, the results from the third subject can be used to correct this mismatch.

Not all organizations perceive the RE process to be essential. According to the theory, the RE process is very important. Correcting a requirement conflict in a later phase can cost up to 200 times as much as when it would have been resolved during the RE process (Boehm, 1981). According to one of the experts, however, the majority of the organizations do not perceive the RE process to be essential, but as a cost and time expensive phase with little result. Because of this mismatch, we advise to perform a research on the following subjects:

1. The incentives of organizations to pay little attention to the RE process
2. The correctness of Boehm's results in the context of current software development projects
3. Procedures to encourage organizations to pay more attention to the RE process

The results of the first two subjects can be used to check if the mismatch between theory and practice stems from outdated assumptions in theory or from incorrect assumptions in practice. Based on these results, conclusions can be drawn about the necessity of organizations to pay more attention to the RE process. If this necessity exists, the results from the third subject can be used to correct this mismatch.

16. Recommendations

We advise members of KPMG to use the developed method when they have to assess the quality of the RE process and we advise KPMG to make their members aware of the existence of the developed method and to store the method in a place where every member can find it.

The developed method is complete and can be used by members of KPMG to assess the quality of the RE process. The method checks the main aspects concerning planning, budget and the quality of the solution. Furthermore, the method is complete and easy enough for new members that have never reviewed the RE process before, and it can be used as a reminder for members that have reviewed the RE process before.

Members of KPMG should know that the developed method exists and where it can be found, else they will not use it. The first aspect can be reached by notifying members about the existence of the method. For example, in emails or project meetings. The second aspect can be reached by storing the method in a central place. For example, close to the documentation related to project reviews. Finally, it is important that the members have access to the method.

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Appendix A: Proposed Method

Appendix A is confidential and therefore not available to the public.

Appendix B: Improved Method

Appendix B is confidential and therefore not available to the public.

Appendix C: Final Method

Appendix C is confidential and therefore not available to the public.

Appendix D: Results of the Validation

Results Case C

Based on case C, the member of KPMG came to the following remarks with regard to the completeness of the method:

1. The checklist does not check that all stakeholders have a clear understanding of the to-be situation (through workshops/presentation etc.)
2. The checklist does not check that stakeholders have evaluated the correctness of requirements (through workshops etc.)
3. The checklist does not check on close cooperation between architect, IT and users
4. The checklist does not check if the project is divided into different phases and that these phases are specified correctly
5. The checklist does not check on a clear sign-off procedure
6. The checklist does not check that process flows are documented
7. The checklist does not check that documentation is available concerning choices and decisions that are made
8. The checklist does not check that high-level requirements are documented
9. The checklist does not check on the clearness of diagrams and tables

The member came to the following remarks with regard to the usefulness of the method:

10. The method itself is good
11. When the remark with regard to the completeness of the method are processed, the method will be complete and can be used by everyone that has to perform a review of the RE process

Results Case D

Based on case D, the member of KPMG came to the following remarks with regard to the completeness of the method:

1. In step 1 of the method, the aspects should be explained in more detail
2. The checklist does not check that high-level requirements are documented
3. The checklist does check on attention paid to cultural differences, 'local differences' may be a better formulation
4. The method does not make a distinction between process aspects and content aspects in the RE documentation

The member came to the following remarks with regard to the usefulness of the method:

5. In most projects, no or minimal RE documentation is available, making the quality of the information in the RE documentation not important
6. The method can be used by everyone that has to perform a review of the RE process

Results Case E

Based on case E, the member of KPMG came to the following remarks with regard to the completeness of the method:

1. The checklist does check on traceability of information, 'the reasons behind requirements and decisions are given' may be a better formulation
2. The checklist does not check if the project is divided into different phases and that these phases are specified correctly

The member came to the following remarks with regard to the usefulness of the method:

3. The method is complete and easy enough for new members that have never reviewed the RE process before
4. It is good that the method checks on planning and testing

Results Case F

Based on case F, the member of KPMG came to the following remarks with regard to the completeness of the method:

1. The checklist does not check that all stakeholders have a clear understanding of the to-be situation (through workshops/presentation etc.)
2. The checklist does not check if the project is divided into different phases and that these phases are specified correctly
3. The checklist does not check that, in case of delivery of the product in different phases, the business process are still performing as they should do
4. The checklist does not check that the level of detail in the requirements specification matches
5. The checklist does not check on a clear sign-off procedure
6. The checklist does check on attention paid to cultural differences, 'local differences' may be a better formulation
7. The checklist does not check that it is clear which documentation is available
8. Concerning unambiguousness of information, this can be done by adding a glossary to the RE documentation
9. Concerning consistent information, this means for content, document templates etc.
10. Concerning traceability of information, 'the reasons behind requirements and decisions are given' may be a better formulation
11. In step 4 of the method, no question is asked about the reasons behind the conclusion and recommendations
12. The classification in risks is good, but risk three to six do overlap on some aspects (a classification of risks and topics combined maybe better)
13. It is not necessary that the topics in both checklists matches

The member came to the following remarks with regard to the usefulness of the method:

14. The method is useful and can be used in many projects

15. It is good that the checklist checks on the quality of the information in the RE documentation
16. The method can be used by everyone that has to perform a review of the RE process: the method is complete and easy enough for new members that have never reviewed the RE process before, and it can be used as a reminder for members that have reviewed the RE process many times before

Results Case G

Based on case G, the member of KPMG came to the following remarks with regard to the completeness of the method:

1. The checklist does not check that high-level requirements are documented
2. Concerning the realistic costs specification, this can be checked by looking at, for example, the invoices
3. Concerning the non-functional requirements, privacy aspects and governmental regulation are important to check

The member came to the following remarks with regard to the usefulness of the method:

4. The method is complete and easy enough for new members that have never reviewed the RE process before
5. It is important that the members know that this method is available and that the method is stored on a place the members can find

Results Case H

Based on case H, the member of KPMG came to the following remark with regard to the completeness of the method:

1. The checklist does not check on a close cooperation between users and developers, this is important especially during the testing phase

The member came to the following remarks with regard to the usefulness of the method:

2. Step 4 is good, it shows how the checklists in the method can be used to draw a conclusion and formulate recommendations
3. The method can be used by everyone that has to perform a review of the RE process: the method is complete and easy enough for new members that have never reviewed the RE process before, and it can be used as a reminder for members that have reviewed the RE process many times before
4. The method is applicable for many projects KPMG performs reviews on
5. It is important that the members know that this method is available and that the method is stored on a place the members can find it