Requirements elicitation in goal oriented requirements engineering

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Dissertation submitted in *partial* fulfilment of the requirements for the degree *Magister Scientiae* in Computer Sciences and Information Systems at the Potchefstroom Campus of the North-West University

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November 2015

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It all starts here ™

ACKNOWLEDGEMENTS

First and foremost, I praise God, my Heavenly Father, for providing me with strength and ability throughout the study.

I would like to thank Prof. Magda Huisman for the opportunity to conduct the research as well as all her patience, support and guidance throughout the research process.

I would also like to thank Mrs. Wilma Breytenbach for her assistance with the statistical analysis, and Kareni Bannister for language editing.

To my friends, thank you for your support during this difficult time. The encouragement and advice you gave me is gratefully appreciated. Special thanks to Petrie and Jaco for extra guidance and motivation during the study. To Nico Beukes, thank you for our friendship and the support. The constant motivation, guidance and help you provided throughout the study meant the world and will not be forgotten. Finally, Anneke Stols, thank you for everything you have done for me through this difficult time. Your love and support will always be remembered.

To my parents, Gys and Anel, and my brother and sister, Thiaan and Karin, thank you for the love and the support you have given me throughout my life, especially during the years at university that led to this research project. The love and motivation will always be remembered.

The financial assistance of the National Research Foundation towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at are those of the author and are not necessarily to be attributed to the National Research Foundation

ABSTRACT

The purpose of the study is to identify shortcomings of requirements elicitation when implementing goal oriented requirements engineering (GORE) methods. Ultimately a framework will be created to address the shortcomings identified. The objective of the framework is to provide guidelines for the implementation of the requirements elicitation phase when a GORE method is used.

The ever-changing environment of information technology results in changes in requirements throughout the development life cycle. The need to adapt to these changes produced agile systems development methodologies. As a result of these more adaptive systems development methods, goal oriented requirements engineering (GORE), was introduced. This technique relies on goals being established and requirements extracted from these goals. Requirements elicitation is a phase of the Requirements Engineering (RE) process and encompasses activities to do with obtaining the requirements of the new system from various sources. In order to identify specific shortcomings in terms of requirements elicitation in GORE, current frameworks/methods need to be evaluated and studied. The study will help to create a new framework based on current best practices. This framework will help to provide solutions for the limitations, which are needed because most of the current models focus on different aspects of GORE and not on the elicitation phase.

The positivist research paradigm indicated the use of questionnaires as the main method of data collection. Statistical data analysis provided results that gave descriptive information about the implementation of GORE methods and showed how their use compared with that of traditional RE. From these results, the main components were identified. They include elicitation techniques, communication, changes in requirements, and the interaction with the other phases within GORE. Each of these components indicated a strong relationship with the requirements elicitation phase. The framework, based on these components, provides guidelines for the requirements elicitation phase and indicates possibilities for future research into this subject.

Keywords: Requirements engineering, goal oriented requirements engineering, requirements elicitation, requirements communication, requirements changes, systems development, requirements elicitation techniques, GORE methods, requirements elicitation framework.

OPSOMMING

Die doel van die studie is om tekortkominge te identifiseer tydens die implementering van doelgerigte vereistes ingenieurswese (GORE) metodes. 'n Raamwerk sal geskep word om die tekortkominge wat geïdentifiseer is, aan te spreek. Die doel van die raamwerk is om riglyne te verskaf vir die implementering van die vereistes verkrygings fase tydens die gebruik van GORE metodes.

Die aanhoudende veranderende omgewing van inligtingstegnologie, veroorsaak dat daar veranderinge in die vereistes regdeur die ontwikkelingsproses ontstaan. Die behoefte om aan te pas by die veranderinge het gelei tot stelsels ontwikkelingsmetodologieë wat gefokus is op vinnige ontwikkeling. As gevolg van hierdie meer aanpasbaar stelsels ontwikkeling metodes was GORE bekendgestel. GORE metodes werk deur eers doelwitte te identifiseer en dan vereistes vanuit hierdie doelwitte te genereer. Vereistes verkryging is 'n fase van vereiste ingenieurswese wat al die aktiwiteite bevat wat te doen het met die identifisering en verkryging van vereistes van verskillende bronne vir die stelsel wat ontwikkel word. Met die doel om spesifieke tekortkominge in terme van die vereistes verkryging in GORE te identifiseer, sal huidige raamwerke en metodes geëvalueer en bestudeer word. Die studie sal 'n nuwe raamwerk skep, gebaseer op huidige beste praktyke. Hierdie raamwerk sal help om oplossings te bied vir die beperkings, omdat meeste van die huidige modelle slegs fokus op verskillende aspekte van GORE, en nie op die vereistes verkryging fase nie.

Die implementering van die positivistiese navorsings paradigma het die gebruik van ʼn vraelys gemotiveer. Statistiese data-analise was gebruik om resultate te bereken wat beskrywende inligting verskaf het oor die implementering van GORE metodes. Die resultate het ook gewys hoe die gebruik van GORE vergelyk met dié van tradisionele RE. Die resultate was gebruik om die belangrikste komponente te identifiseer vir die raamwerk. Die komponente sluit die volgende in: Verkrygings tegnieke, kommunikasie, veranderinge in die vereistes, en die interaksie met die ander fases van die GORE proses. Elkeen van hierdie komponente het 'n sterk verhouding met die vereistes verkrygings fase getoon. Die raamwerk, wat gebaseer is op hierdie komponente, bied riglyne vir die implementering van die vereistes verkryging fase tydens die gebruik van GORE. Moontlike toekomstige navorsing in hierdie onderwerp word ook geïdentifiseer.

Sleutelwoorde: Vereistes ingenieurswese, doelgerigte vereistes ingenieurswese, vereistes verkryging, vereistes kommunikasie, vereistes veranderinge, stelsels ontwikkeling, vereistes verkrygings tegnieke, GORE metodes, vereistes verkrygings raamwerk.

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CHAPTER 1 – RESEARCH PROBLEM

1.1 INTRODUCTION

The information system development process consists of various phases, which include requirements elicitation, requirements analysis, requirements specification, and requirements validation (Westfall, 2006:10). The requirements elicitation phase is concerned with the requirements of the system being developed. In addition to the requirements the, constraints of the system are also identified. Requirements Engineering (RE) involves the goals of a system, as well as the constraints of the system (Nuseibeh & Easterbrook, 2000:35; Zave, 1997:315). This process is seen as one of the most important stages of the development of information systems and during this phase a balance needs to be maintained between technical considerations and the organisational and social considerations. Finding this balance will result in the moulding of the operation environment in which the information systems will be built (Castro *et al.,* 2002:366).

The ever-changing environment of information technology results in alterations in requirements throughout the development life cycle. The need to adapt to these, changes agile systems development methodologies. The result of these more adaptive systems development methods, was the introduction and use of goal oriented requirements engineering (GORE), in various projects (van Lamsweerde, 2004:5). This technique relies on goals being established and requirements extracted from these goals (Lapouchnian, 2005:4). Agents (stakeholders/ systems/ etc.) are responsible for achieving these goals and can influence one another. GORE developed at a rapid rate and various GORE models were introduced, which include Knowledge Acquisition in autOmated Specification (KAOS), Goal-Based Requirements Analysis Method (GBRAM), Annotated Goal Oriented Requirements Analysis (AGORA), Non-Functional Requirement (NFR), and the distributed intentionality framework (i*) (Horkoff & Yu, 2013:200; ur Rehman *et al.,* 2013:40). Each of these was introduced in order to address some shortcoming in GORE.

1.2 PROBLEM STATEMENT

From the abovementioned models or methodologies (and traditional RE) it is evident that requirements elicitation still presents a hurdle in RE due to communication issues of such requirements as well as the often vague and informal nature of the requirements (Horkoff & Yu, 2011:680; Lapouchnian, 2005:13) The Chaos Manifestos of 2013 and 2014 also suggest that RE is an important reason for project failure due to incorrect or incomplete identification of requirements (Standish Group, 2013; Standish Group, 2014).

Requirements elicitation is a phase of the RE process and encompasses activities to do with obtaining the requirements from the various sources (Sen & Hemachandran, 2010:16). Elicitation techniques include mind maps, story cards, interviews, etc., and each is appropriate for different situations. These techniques have been studied before, but research on their application in GORE is still limited. Stakeholder communication also forms an important part of the requirements elicitation phase (Horkoff & Yu, 2011:680; Lapouchnian, 2005:20). Stakeholder communication in the requirements elicitation phase in traditional RE is evident in research, but to the best of the researcher's knowledge research on communication in requirement elicitation with GORE is scarce. This indicates the gap that can be filled through the study. Furthermore, the sources of requirements stretch well beyond the stakeholders (people) and thus these aspects (such as current systems, documents, etc.) should also be investigated because they influence each other.

In order to identify the specific shortcomings in terms of requirements elicitation in GORE, current frameworks/methods must be evaluated and studied. The study will help to create a new framework based on current best practices and provide guidelines for the limitations, as most of the current models focus on different aspects of RE and none on the elicitation methods. The creation of the framework will contribute to both the industry as well as the academia. The industry contribution is that the framework will provide guidelines for the requirements elicitation phase during the implementation of GORE methods. The academic contribution is that the framework will identify components of the requirements elicitation phase in GORE that promotes future research.

1.3 RESEARCH AIMS AND OBJECTIVES

The aim of the research is to develop a theoretical framework to be used within GORE with the focus on requirements elicitation. In order to develop this framework, the following objectives had to be completed:

1. Identify the current state of the GORE method use.
2. Identify critical aspects that should be addressed in GORE methods.
3. Identify key components and the shortcomings of the requirements elicitation process followed in various GORE methods.
4. Develop a framework that will address the problems identified in objectives 2 and 3.
5. Make recommendations based on the findings for future research.

1.4 RESEARCH METHODOLOGY

The research methodology of the study consists of a literature review, data collection and analysis. The literature review will be done on the following subjects:

- Requirements engineering,
- Goal oriented requirements engineering

In addition to the literature review, the following components will be used as data collection and analysis:

Proposed design: The research paradigm that will be used during this study will be the positivistic research paradigm. This research paradigm is most suited for the creation of the framework. The use of a survey will be applied during the research.

Data acquisition: Data acquisition will be done in the form of a questionnaire. A conceptual model will be created which will be used to determine the questions. The following will be the characteristics of the questionnaire:

- The questionnaire will be in electronic form.
- The target group of the questionnaire will be developers as well as project managers in an information systems development field.

The questionnaire will be used in order to gather information regarding the use GORE methods. How GORE is implemented, to what degree is it implemented, how long the organisation has used the GORE methods, etc. are all points of interests. Furthermore, these questionnaires will be answered anonymously in order to comply with the ethics standard. Statistical analysis will be used in order to process the data and extract the necessary information.

1.5 DISSERTATION OUTLINE

Subsequent to this introductory chapter and problem statement which led to the research being done, the dissertation also includes the following chapters:

Chapter 2: Literature Review

This chapter includes two sections which provide an overview of current literature. These two sections include:

a. Literature study on requirements engineering;

b. Literature study on goal oriented requirements engineering

Chapter 3: Research methodology

This chapter provides a description of how the research was undertaken and how the data was analysed. It will include:

a. A description of the research paradigm used;

b. A description of the data collection methods used; and

c. A description of the statistical data analysis applied.

Chapter 4: Results of data analysis and discussion of research objectives

The results of the study are provided and interpreted in this chapter, after which the results are discussed in accordance with the research objectives.

Chapter 5: Proposed framework

In Chapter 5 the framework that was created on the basis of the results is presented and discussed.

Chapter 6: Conclusion, limitations and recommendations

To conclude, the final chapter debates how well the objectives have been met in this study. The limitations of the study are noted and recommendations are provided for future research.

1.6 CONCLUSION

This chapter introduced all the different components that is relevant in the study. The problem was identified and a solution suggested. In order to provide the solution, certain aims and objectives must first be completed. Finally, the research method that will be used during the study was also described. Chapter 2 will begin the research with the literature overview of RE and GORE.

CHAPTER 2 – LITERATURE REVIEW

Chapter 2 will provide the literature review that was part of the study. The first section, Section 2.1, will discuss the literature relevant to RE and will include the following.

- What RE is;
- The types of requirements; and
- The RE process and the different phases of the RE process.

Section 2.2 will focus on GORE and will include the following:

- What GORE is;
- The GORE process; and
- Different GORE methods.

2.1 REQUIREMENTS ENGINEERING

2.1.1 INTRODUCTION

The term Requirements Engineering (RE) in software engineering is used to describe that part of development which deals with the functionality or the goal of the system being developed (Zave, 1997:315). RE is an important part of the development process and this section will provide a literature overview of RE. The first part will discuss the definition of RE in more detail. A description of the different types of requirements will follow. The discussion of different activities carried out during RE will then be discussed.

2.1.2 WHAT IS RE?

Ebert (2006:102) describes requirements as the basic building blocks of the system being developed. These requirements interlink the different phases of the development process. Ebert (2006:102) sums up RE as:

> *"…the sum of all activities needed to define, develop, implement, build, operate, service, and phase out a product and its related variants."*

Furthermore, Zave (1997:315) provides one of the most popular definitions for RE, as:

> *"Requirements engineering is the branch of software engineering concerned with the real-world goals for functions and constraints on software systems. It is also concerned with the relationship of these factors to precise specifications of software behaviour, and their evolution over time and across software families."*

On closer inspection the definition of Zave (1997:315) shows that three different parts are addressed. The first part is "*real-world goals*", the second "*precise specifications*", and the last one is the "*evolution over time and across software families*" (Nuseibeh & Easterbrook, 2000:35). These different parts will be discussed next.

2.1.2.1 REAL-WORLD GOALS

Nuseibeh and Easterbrook (2000:35) describe real-world goals as the *"what"* and the *"why"* of the system. It is thus important to know and understand what needs to be done before the building of the software starts (Sampaio do Prado Leite & Freeman, 1991:1253; Lapouchnian, 2005:1). The users and customers as well as the organisation that is building the system must also accept these goals before it can be built, (Westfall, 2006:1). Westfall (2006:1) goes on to describe the three aspects of the *"what"* in RE.

1. *"What the software must do"* - this will include the functional requirements (this will be discussed in Section 2.1.3.3) and will describe the capabilities of the system.
2. *"What the software must be"* - this will include the non-functional requirements (this will be discussed in Section 2.1.3.4) and will describe how well the system performs in completing the capabilities mentioned in the previous point.
3. *"What limitations there are on the choices"* - this is in terms of system implementation. Various factors can influence this, such as the external environment and other constraints.

Brooks (1995:199) also contributes with the following quotation:

> *"The hardest single part of building a software system is deciding precisely what to build. No other part of the conceptual work is so difficult as establishing the detailed technical requirements, including all the interfaces to people, to machines, and to other software systems. No other part of the work so cripples the resulting system if done wrong. No other part is more difficult to rectify later. "*

From this quotation it is clearly evident just how important this part of RE is. If the "*why*" and "*what"* of the system are not clearly specified and accepted, it could result in very expensive issues later on in the development process. Without the correct "*what*" and "*why*" the program may be built exceptionally well but it will be the wrong product (Westfall, 2006:3).

2.1.2.2 PRECISE SPECIFICATIONS

This section is described by Nuseibeh and Easterbrook (2000:35) as the part which enables specification analysis and provides the possibility of validating the requirements in terms of how well they satisfy the need of the stakeholders. It also provides design guidelines and verification for the designers of the software. This implies, that, in addition to the guidelines being provided, the design can also be verified. Nuseibeh and Easterbrook (2000:35) highlighted the following terms in the above statement:

- **Analysing specifications** - This process involves stakeholders such as the systems analyst and the end users. These stakeholders will try to identify the information and data needed to build the desired system (Byrd *et al.,* 1992:117). The task of requirements analysis is a fairly common subject of interest and this is evident in the literature (Mylopoulos *et al*., 1999:31; Antón, 1996:136). Requirements analysis is one of the activities in RE and will be discussed in section 2.1.4.2 (Lapouchnian, 2005:1).

- **Requirements validation** - The process of requirements validation attempts to verify that the requirements created and established are complete. This process will also prevent errors from being made during software development by identifying them beforehand (Kotonya & Sommerville as cited by Raja, 2009:1). Raja (2009:1) states that this process is the last phase in the RE process, and that requirements validation will resolve issues with *"ambiguous requirements"* as well as other conflicts regarding RE.

The more precise the requirements are, the better the system will provide for the needs of the stakeholder. Requirements analysis as well as requirements validation helps to ensure the precision of the requirements. These processes thus ensure that the requirements are complete and correct, as well as consistent (Bahill & Henderson, 2005:2).

2.1.2.3 EVOLUTION OVER TIME AND ACROSS SOFTWARE FAMILIES

This section focuses on the reality that the world changes. This means that there is a great possibility that the requirements and needs of the stakeholders will also change throughout the development process. The need to reuse certain parts of specifications is also emphasised

(Nuseibeh & Easterbrook, 2000:35). Harker *et al.* (1993:268) describe some of the origins of the changes in requirements that occur:

- **Mutable requirements** - The changing environment in which organisations function is the main contributor to this type of requirement changes. Changes in the environment include market changes, evolution of development technique and technologies, changes in government policies, changes in management, etc. (Harker *et al.,* 1993:268). Thus, the changes in requirements are a result of changes that occur outside the development process and the system being developed.

- **Emergent requirements** - The initial requirements specification created at the start of development process normally contains vague requirements or is incomplete. This is a result of stakeholders not knowing precisely what it is they want the system to do. It takes time for the stakeholders to identify their goals and needs for a new system. New requirements emerge as a result of the progression in the development process of the system (Harker *et al.,* 1993:268). Organisations sometimes respond to these emerging requirements by adopting a new development method (Boehm, 2002:69).

- **Consequential requirements** - These types of requirements emerge as a result of the users' experience with the new system. This can occur after the system has been built or even during the development. The user can identify new features of a system as it is being used or the development team can identify new enhancements/upgrades to the system after its delivery - all this happens after the development. The use of prototypes during development can also lead to these types of requirement changes (Harker *et al.,* 1993:268).

- **Adaptive requirements** - Implementing a new system can result in an organisation identifying new ways in which the system may be used within the organisation. This can ultimately result in new requirements because the system must be able to adapt to these new functions. The delivered system must also be adaptable for future upgrades or for other changes in the organisation (Harker *et al.,* 1993:268).

Changes in requirements are bound to occur during the development process (Boehm, 2002:69; Nuseibeh & Easterbrook, 2000:35; Harker *et al.,* 1993:268). Organisations try to implement different development methods in order to mitigate these changes (Boehm, 2002:69).

The above definitions and the discussion took a closer look at what RE is and why it is needed. This process is necessary for every new project and will contribute greatly to its success. From this discussion, RE may be described as the part of development process, whether at the beginning, in the middle or at a later stage, that describes what tasks need to be done and how they should be done. This description must also indicate who should do said tasks. Ultimately, without RE, the development team will not be able to provide what stakeholders need in order to deliver a successful system.

2.1.3 TYPES OF REQUIREMENTS

The discussion about the identity of and need for RE prompted the identification of different types of requirements within the RE process. As mentioned, these include functional requirements and non-functional requirements. Westfall (2006:2) provided the illustration in Figure 2-1, depicting the different levels and types of requirements.

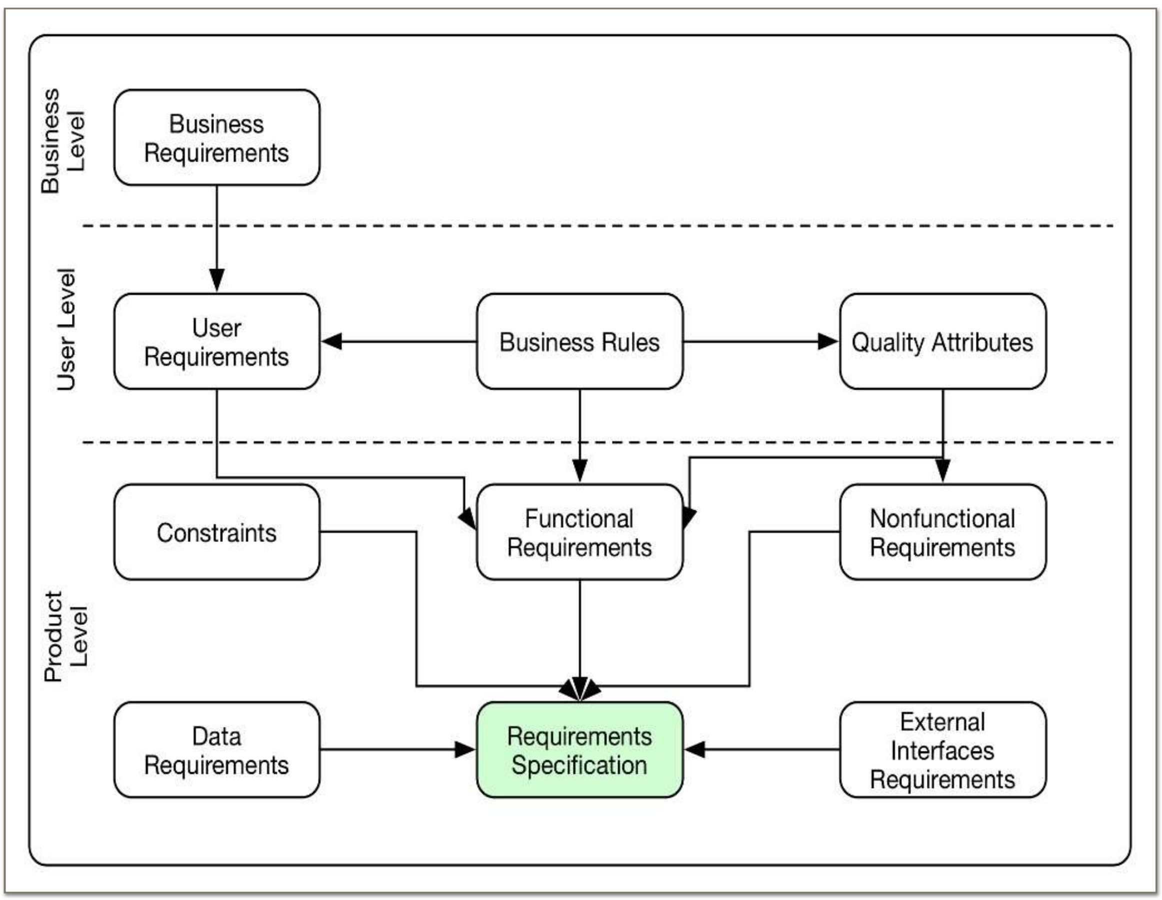

Figure 2-1: Levels and types of requirements (Westfall, 2006:2)

2.1.3.1 BUSINESS REQUIREMENTS

Kazhamiakin (2004:10) describes business requirements by using the *"what*" and *"why"* keywords. These include the characteristics of the business process related to the organisations' strategy and rationale. Normally, the focus lies on the implementation of these business processes ("*the how*") rather than on the *"what*" and *"why"*. This description, the business requirements, is completed before a specific business process is selected (*"the how"*), as the description will provide motivation for the system being built. These requirements are used to define the problem within the organisation that needs to be addressed by developing a new software system (Westfall, 2006:1). Westfall (2006:1) also mentions that this need not be a problem but can instead identify an opportunity, which can be leveraged by developing a new software system. These business requirements are described in terms of the objects of the organisation or customer. Westfall (2006:1) also uses the *"why"* keyword in the definition of business requirements:

> "*In general, the business requirements define why the software product is being developed."* Westfall (2006:1)

2.1.3.2 USER REQUIREMENTS

The user requirements refer to the needs of the user rather than to the system being developed. This means that the user wants to accomplish some task and the means by which the task is accomplished can result in a new system. How this is done is not relevant at this point (Maiden, 2008:90). Maiden (2008:90) defines user requirements as a stakeholder's need that may result in a new property of a certain business process being introduced if a new system is implemented. Westfall (2006:2) furthermore describes these requirements as the functionality of the system being developed in terms of the perspective of the user. Thus these requirements will describe what the new system must do in order for the user to achieve his/her goals. User requirements also link with the business requirements, as illustrated in Figure 2-1. Westfall (2006:2) describes the relationship whereby single business requirements can result in various user requirements. The example provided by Westfall (2006:2) to explain this relationship, is the following:

- A business requirement might be that a user must be able to pay for his/her fuel at the pump. When implementing this requirement, various user requirements will emerge. This includes the ability to swipe a bank card, enter the pin number for the bank card, and receive a receipt for the fuel purchased. This example clarifies the explanation given by Maiden (2008:90). The business process, paying for fuel at the pump, will gain an extra property. The newly identified properties can include the ability to swipe the bankcard, etc. This example shows, as mentioned by Maiden (2008:90), that the important part here is what needs to be done, not how it is done.

2.1.3.3 FUNCTIONAL REQUIREMENTS

Aurum and Wholin (2005:4) provide a short and simple description of functional requirements: these requirements explain what the system will do. Westfall (2006:2) describes how functional requirements must be built into the product in order to enable the user to achieve his/her tasks, which will ultimately satisfy the business requirements. This will also define the functionality of the system. One user requirement can expand into multiple functional requirements. Westfall (2006:2) expands the example mentioned in section 2.1.3.2 to include functional requirements. The user requirement, the ability to swipe a bank card, can branch into the functional requirements, such as a prompt to the user to swipe the bank card. Detecting the swipe of the card as well as faulty swipes and reading the information from the magnetic strips are also functional requirements derived from the user requirement.

The functional requirements andthe non-functional requirements (which will be discussed next), are important characteristics that must be examined in order to deliver a quality software system that adheres to the needs of the user.

2.1.3.4 NON-FUNCTIONAL REQUIREMENTS

In reviewing the literature, the definition and description of non-functional requirements shown to be difficult (Chung & Do Prado Leite, 2009:364; Glinz, 2007:22). Chung & Do Prado Leite (2009:364) and Glinz (2007:22) both put a lot of emphasis on this and highlight the following list of definitions:

> *“Describe the non-behavioural aspects of a system, capturing the properties and constraints under which a system must operate.”* (Glinz, 2007:22)
>
> *“The required overall attributes of the system, including portability, reliability, efficiency, human engineering, testability, understandability, and modifiability.”* (Glinz, 2007:22)
>
> *“A requirement that specifies system properties, such as environmental and implementation constraints, performance, platform dependencies, maintainability,*

> *extensibility, and reliability. A requirement that specifies physical constraints on a functional requirement."* (Glinz, 2007:22)

> *"Requirements which are not specifically concerned with the functionality of a system. They place restrictions on the product being developed and the development process, and they specify external constraints that the product must meet."* (Glinz, 2007:22)

These requirements are also referred to as the "*-ilities*" or "*-ities*". This implies that things that end on these words are normally seen as non-functional requirements. Westfall (2006:10) describes how the quality attributes (at user level in Figure 2-1) will result in non-functional requirements and will define the quality of the system. This can include the following characteristics:

> "*…reliability, availability, security, safety, maintainability, portability, usability, and other properties.*" (Westfall, 2006:2)

The characteristics provided indicate where the "*-ilities*" and "*-ities*" come from. Glinz (2007:22) adds to this by stating that although some of the terms may contain the above-mentioned word endings, there are non-functional requirements that do not have these endings (as seen in the provided characteristics). It is also important to note that the quality attributes can result in functional requirements (as discussed above) as well as non-functional requirements (Ernst *et al.*, 2007:3). Westfall (2006:2) provides the following examples to explain how this may occur:

- The first example is given in the form of the quality attribute which means that the system must be easy to understand. This quality attribute (which is at user level in Figure 2-1) may result in the functional requirement which requires the system to show a clear pop-up message when an error occurs. The pop-up is thus a function the system must contain.
- The second example is again a quality attribute, which is that the system must be easy to use. This quality attribute can result in a non-functional requirement that will require the system to respond fast to user input and certain requests.

Ernst *et al.,* 2007:3 describe a non-functional requirement as something that will not change the functionality of the system but rather, for example, change its maintainability. Furthermore, these non-functional requirements normally tend to affect the whole system rather than just a certain part.

2.1.3.5 DATA AND EXTERNAL INTERFACE REQUIREMENTS

- **Data requirements** - Westfall (2006:2) describes these as the specific data structures or certain data items that will be needed in order to use the system being developed.

- **External interface requirements** - Westfall (2006:2) describes these as the information flow between different systems, the different hardware and software, and the different users. Any requirements regarding the aspects mentioned previously will be categorised under this section.

2.1.3.6 MORE CLASSIFICATIONS

In addition to Figure 2-1, Aurum and Wholin (2005:4) provided Table 2-1 which describes their classification of different types of requirements. The main difference between Table 2-1 and Figure 2-1 is the different categories of requirements. Westfall (2006:2) categorized the requirements in three different categories while Table 2-1 illustrates a deeper classification of the requirements.

Table 2-1: Requirements classification (Aurum and Wholin, 2005:4)

• Functional requirements - *"what the system will do."* • Non-functional requirements - *"constraints on the types of solutions that will meet the functional requirements, e.g. accuracy, performance, security, and modifiability."*
• Goal level requirements - these are related to the business goals. • Domain level requirements - these are related to the problem area. • Product level requirements - as the name suggests, these are for the product being developed. • Design level requirements – these will describe what needs to be built.
• Primary requirements - these will be extracted from the stakeholders. • Derived requirements - these will be derived from the primary requirements.
Other classifications, e.g.

- Business requirements versus technical requirements
- Product requirements versus process requirements
- Role-based requirements

2.1.3.7 CONCLUSTION

The different types of requirements, as discussed above, indicated how vastly this process of RE stretches when developing a new software system/product. When a new system is being developed, it affects not only the organisation developing the software system/product but also other environments. In order to get a clearer perspective of how RE is carried out, the next section will cover the different processes involved.

2.1.4 THE REQUIREMENTS ENGINEERING PROCESS

The next part of discussion will take a closer look at the RE process and how it is performed. After the discussion on what RE is and what types of requirements there are, it is also important to look at how all of this interlink and implemented. Nuseibeh and Easterbrook (2000:35) list the following as the core activities (also referred to as phases) that are evident in the RE process:

- Eliciting requirements;
- Modelling and analysing requirements;
- Communicating requirements;
- Agreeing requirements; and
- Evolving requirements.

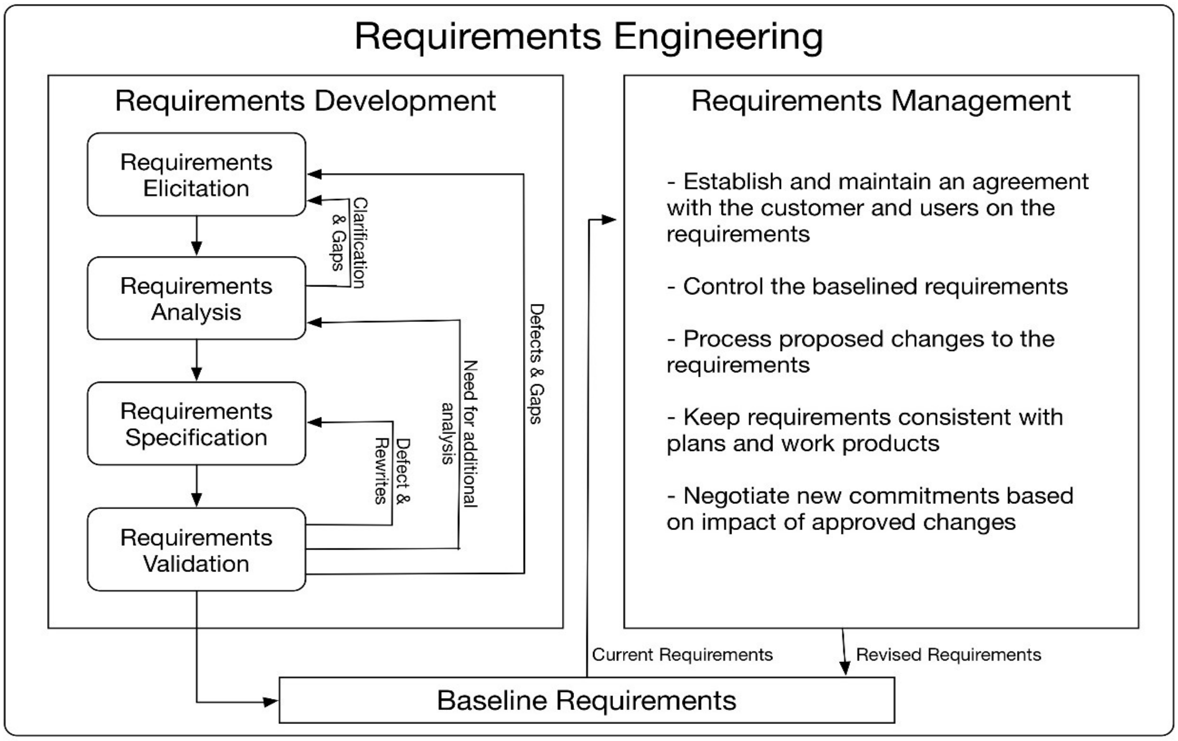

Figure 2-2: Requirements engineering process (Westfall, 2006:10).

In addition to these processes, Westfall (2006:10) also provided a collection of activities. They are depicted in Figure 2-2. Westfall (2006:10) created this illustration from information provided by Wiegers (2004). The RE process is divided into two parts, requirements development and requirements management. Aurum and Wohlin (2004:5) list the following activities as part of the RE process:

- Elicitation of requirements;
- Interpretation and structuring (analysing and documenting the requirements);
- Negotiating requirements;
- Verification and validation of requirements; and
- Management of changes in the requirement.

- Requirements tracing

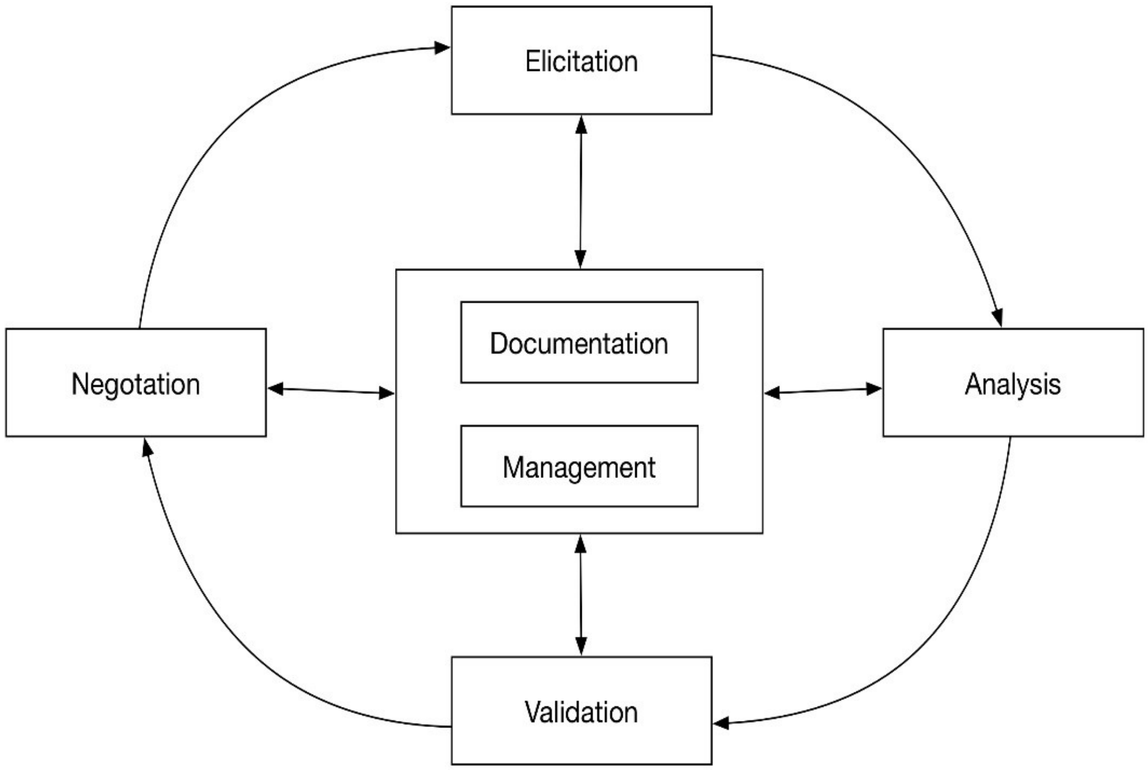

Figure 2-3: Requirements engineering activity life cycle (Sommerville, 2005:17)

Sommerville (2005:17) also provides an illustration, as shown in Figure 2-3, in order to depict the activities in the RE process. Figure 2-3 provides yet another illustration of the different activities that may be found within the RE process. In order to discuss these different activities, a common set of activities must be chosen. For the purpose of this literature review, the following activities will be used as main focus points of discussion: requirements elicitation and requirements analysis.

2.1.4.1 REQUIREMENTS ELICITATION

The first step in all of the above-mentioned activities is requirements elicitation. Simply put, requirements elicitation has to do with gathering and defining the different needs or objectives of the stakeholders and other applicable parties. Lapouchnian (2005:1) defines requirements elicitation as:

> *"Elicitation: alternative models for the target system are analysed to meet the identified objectives. Requirements and assumptions on components of such*

models are identified. Scenarios could be involved to help in the elicitation process."

The above definition, when examined more closely, agrees with the statement that requirements elicitation has to do with gathering and defining the different needs or objectives of the stakeholders. The first part of the definition describes how alternative models must be analysed, which points to different sources. The objectives mentioned in the definition will ultimately evolve into the requirements for the system being developed. In addition to the provided definition, Horkoff and Yu (2011:679) also offer a description of requirements elicitation. Requirements elicitation is a process used to identify *"higher level requirements"* in order to provide a system that is more complete. By involving users in this process, deficiencies as well as other needs can be elicited. Furthermore, Westfall (2006:10) defines the elicitation process (with regard to Figure 2-3) as follows:

"The requirements elicitation step includes all of the activities involved in identifying the requirement's stakeholders, selecting representatives from each stakeholder class, and determining the needs of each class of stakeholders. This elicitation process is the information-gathering step in the requirements development process."

This definition, again, points out the importance of gathering information regarding the system being built and about the stakeholders that are involved in the development process.

2.1.4.1.1 TYPES OF REQUIREMENTS ELICITATION TECHNIQUES

Gathering the requirements is an important action and there are various ways in which this can be done. Table 2-2 provides some of the more popular techniques that can be used to elicit requirements. A short description of each technique is also provided.

Table 2-2: Requirements elicitation techniques

Elicitation method	**Description**
Interview (Ahmad, 2008:683; Westfall, 2006:10)	The use of interviews is one of the oldest and most popular techniques for eliciting requirements (Zowghi & Coulin, 2005:26). This type of technique is dependent on human interaction and thus the success of this method will rely on the level of interaction between the participants. There are also different types of

	interviews namely structured, semi-structured, and unstructured interviews (Zowghi & Coulin, 2005:26; ur Rehman *et al*., 2013:42). A structured interview is conducted with a set of predefined questions, whereas an unstructured interview is more of a conversation with little predefined structure.
Joint-Application-Devlopment (JAD) (Ahmad, 2008:683; Duggan & Thachenkary, 2004:399)	The use of this elicitation method requires that all stakeholders are present. All stakeholders discuss the problems as well as the solutions (Zowghi & Coulin, 2005:26). Duggan and Thachenkary (2004:399) state that this technique was introduced to improve team rapport and to achieve synergy by involving different participants. This technique is then also seen as a structured technique as the conduct of each session is determined beforehand. This will include the steps involved as well as the definition of actions and roles for each participant (ur Rehman *et al*., 2013:43). ur Rehman *et al*. (2013:40) state this this technique is used to gather the needs of the business and users rather than the technical issues.
Prototyping (Ahmad, 2008:683; Sutcliffe & Sawyer, 2013:92)	Prototypes are part of the system being developed. They can be developed during early stages and can give the client an idea of the completed system. Prototypes can be applied in two ways. Firstly, to identify and describe difficult requirements. These prototypes will not be part of the final system. Secondly, a prototype that will be part of the final system. Not only will this help to elicit future requirements but it will also provide the client with a working part of the system (Paetsch *et al*., 2003:309). Prototypes are often difficult to implement because it requires increased resources and the number of prototypes that can be developed for a system is sometimes limited (Sutcliffe & Sawyer, 2013:92).
Use cases (Ahmad, 2008:683; ur Rehman *et al*., 2013:43)	The requirements are identified through "*story telling*". The complete flow of how the software or system works is communicated to the stakeholders through a "*story telling*" perspective. This type of elicitation is informal and will help the stakeholders to better understand the requirements (ur Rehman *et al*., 2013:43). Furthermore, use cases do not consider the

	internal structure of the system and this results in a need for an incremental and iterative development approach when using this elicitation technique (Zowghi & Coulin, 2005:26). Firesmith (2004:31) describes a use case as an array of paths, which may be normal or exceptional. The normal path is the outcome of a positive action while the exceptional path is the result if the use case fails.
Story boards (Ahmad, 2008:683)	Vogt (2013:41) defines a story board as a visual method through which a story is told. The requirements will be in the form of images. These images will depict actual things, such as people, ideas, or places. The manner in which the story board is drawn often illustrates the flow of the story (Vogt, 2013:41). Furthermore, the use of panels is also evident with the use of story boards. Each of the panels plays a specific role in the story and provides a snapshot of a certain moment in the story (Vogt, 2013:42). Story boards are also a means by which the designer can communicate all aspects of the product to all the stakeholders. The product designer will also better understand the context of product, the target group and the use of the product if story boards are used (Van der Lelie, 2006:159).
Workshops (Westfall, 2006:10)	In order to elicit requirements by this method, requirements workshops are organised with the intention to gather the needs and desires of the stakeholder (ur Rehman *et al*., 2013:43). Requirements are gathered only after a few sessions have been completed and not after each session. This means that it will be difficult to change the requirements because they are only gathered at the end of this process. This in turn is very time consuming and costly (ur Rehman *et al*., 2013:43). The main focus of these workshops is to identify requirements. There can be different types of workshops depending on the different objectives (Zowghi & Coulin, 2005:30). The objective could be to identify creative aspects or it can be to identify cross-functional aspects which will include different stakeholders from different departments within the organisations. Furthermore, the workshops can also be benfitial for the development team.

Observations (Westfall, 2006:10)	This type of elicitation method is one of the most common ethnographic techniques, that is a technique whereby the individuals are studied in their natural setting (Zowghi & Couling, 2005:30). During an observation the analyst will observe the current practice or execution of a certain process without any interference from the observer. The use of observations has proved to be more successful during the elicitation of tacit goals because this method will produce rich contextual descriptions (Sutcliffe & Sawyer, 2013:94). Observations are also used in conjunction with other elicitation techniques, which can include interviews (ur Rehman *et al*., 2013:44).
Questionnaires and surveys (Westfall, 2006:10; Zowghi & Coulin, 2005:26)	The use of questionnaires is more suitable for the elicitation of requirements during the early phases of development (Zowghi & Coulin, 2005:26). This technique requires the questionnaire designer to create questions that are clear. Questionnaires can also include different types of questions, such as open or closed questions (Zowghi & Coulin, 2005:26). The closed questions are for example yes/no type questions and the open questions will be used to get a more explanatory answer from the participants. This method is less expensive and fairly simple to use (ur Rehman *et al*., 2013:42).

Table 2-2 contains some of the various techniques that can be used to elicit requirements. The techniques selected will depend largely on each individual project, as no two projects are exactly the same. Each project will have different stakeholders with different goals, expectations, etc. and thus the techniques for obtaining these requirements will differ for each different project.

2.1.4.1.2 CATEGORIES OF REQUIREMENTS ELICITATION TECHNIQUES

The techniques used to elicit goals/requirements can further be divided into four distinct categories. ur Rehman *et al*. (2013:42) categorise the elicitation techniques as follows: classical or traditional techniques, cognitive techniques, modern and group elicitation techniques, and contextual techniques.

- **Classical or traditional techniques** - The techniques included in this category are seen as generic data-gathering techniques (Nuseibeh & Easterbrook, 2003:38).
- **Cognitive techniques** - These techniques were originally used to gather knowledge for knowledge-based systems. This knowledge is obtained through the use of various other techniques (Lachana, 2012:2998).
- **Modern and group elicitation techniques** - These techniques try to leverage the knowledge of all the stakeholders by collecting requirements from them while they are in a group (Nuseibeh & Easterbrook, 2003:38). This will require the participants to communicate more openly and freely (Lachana, 2012:2998).
- **Contextual techniques** - This category includes techniques that study the user in the environment in which the system will be implemented (Lachana, 2012:2998).

Table 2-3 summarises the techniques into appropriate categories (ur Rehman *et al.*, 2013:42; Nuseibeh & Easterbrook, 2000:38).

Table 2-3: Categories of requirements elicitation techniques (ur Rehman *et al.*, 2013:42; Nuseibeh & Easterbrook, 2000:38)

Category	**Requirements elicitation method**
Classical or traditional techniques	Interviews, surveys, questionnaires, task analysis, domain analysis, introspection, analysis of existing documents, manuals of existing systems.
Cognitive techniques	Card sorting, Class Responsibility Collaboration (CRC), laddering, repertory grids, protocol analysis,
Modern and group elicitation techniques	Group work, brainstorming, Joint Application Development (JAD), requirements workshops, protocol analysis, prototyping, use cases, scenarios.
Contextual techniques	Ethnographic, observation or social analysis, conversation analysis.

2.1.4.1.3 USAGE OF THE REQUIREMENTS ELICITATION TECHNIQUES

Section 2.1.4.1.1 discussed the different techniques that may be used to elicit goals/requirements. This was followed by the discussion of the different categories into which these techniques are classified. This section will focus on when to apply the techniques. Lachana (2012:3001) provides Table 2-4 which illustrates an extended requirements elicitation model.

Table 2-4: Extended requirements elicitation model (Lachana, 2012:3001)

<table>
<tr><th>Primary tasks</th><th>Elicitation technique</th><th>Supporting tasks</th><th>Participants</th></tr>
<tr><td>Create an initial scope document</td><td>Ethnographic, interview</td><td rowspan="5">• Set up change control
• Use proven techniques
• Engage stakeholders and domain experts
• Documentation of automated tools.
• Peer review and inspect
• Verify and validate
• Continuous improvement
• Share information</td><td rowspan="5">Team
Stakeholders
Experts</td></tr>
<tr><td>Identify actual requirements</td><td>Document/user analysis, prototyping, group elicitation, cognitive, contextual, model-driven</td></tr>
<tr><td>Prioritise and determine releases</td><td>Prototyping, group elicitation, cognitive.</td></tr>
<tr><td>Review and inspect artefacts</td><td>Prototyping, document/user analysis, cognitive.</td></tr>
<tr><td>Iterate requirements development if required</td><td></td></tr>
</table>

The model consists of primary tasks, elicitation techniques associated with the tasks, supporting tasks, and the participants who will complete the tasks. The tasks associated with this model were provided by Young (2002:10). Lachana (2012:2999) then linked the different elicitation techniques with the tasks and the participants. Lachana (2012:2999) created this table not only to address certain problems identified in the requirements elicitation process but also to provide some guidelines for RE practitioners. The problems were identified and, together with other RE models, the above model was created. In addition to this model, Lachana (2012:3001) also provided the following recommended practices to complement the model:

- The first practice mentioned by Lachana (2012:3001) is the concept of training. The participants take part in training sessions in order to identify the best RE approach for the project. These training and discussion sessions will help to identify new approaches and provide clarity on how to use and implement the new approaches.
- The second practice involves storing successful RE approaches of previous projects. These approaches can then be analysed and with the knowledge of the participants from the previous projects be developed to be used with future projects.
- The final practice mentioned by Lachana (2012:3001) is to create sample implementations of the model provided. This, with scenarios, will assist future implementation of the model.

In addition to this model, Hickey and Davis (2003:5) also provide a model focused on requirements elicitation. Figure 2-4 below depicts the details of the elicitation activities provided by Hickey and Davis (2003:5). The model was created by combining two of the most common classes documented, the first being the class that focuses on a specific technique and methodology, and the second class being elicitation models in general (Hickey & Davis, 2003:5). Hickey and Davis (2003:5) added an additional process, the *Elicitation Technique Selection*, which is driven by known requirements, the problems and solution domains, and the project domain. This indicates that for each project the elicitation techniques will differ as the domains will also differ from project to project. The purpose of the model is as follows (Hickey and Davis, 2003:5):

- The model focuses on the importance of knowledge in terms both of the elicitation process and the elicitation technique.
- The model provides a framework that illustrates the importance and role of the requirements elicitation process within the development process.
- This model can be used to represent any elicitation methodology.
- The model indicates how easy it is to tailor current elicitation methodologies to certain scenarios.

Lachana (2012:3000) as well as Hickey and Davis (2003:4) indicate that these models should be implemented in an iterative manner. Figure 2-4 also suggests the concept of iteration as the problem and solution domains are most likely to change during the life cycle of the development. This is also true for the known requirements, as the identification of new requirements will lead to new requirements, which in turn results in this process being carried out again. The above two models (Table 2-4 and Figure 2-4) indicate how the elicitation process may be carried out. Each of these models indicates the different aspects that influence the requirements elicitation process. It is also important to note the differences between these models. Table 2-4 provides a more thorough indication of the different techniques that can be used and of the additional tasks while Figure 2-4 focuses more on the sources of the requirements. These models can thus be followed in order to perform the process more easily with better management but also better results in terms of the requirements gathered. These models will also be used to create the framework for this study.

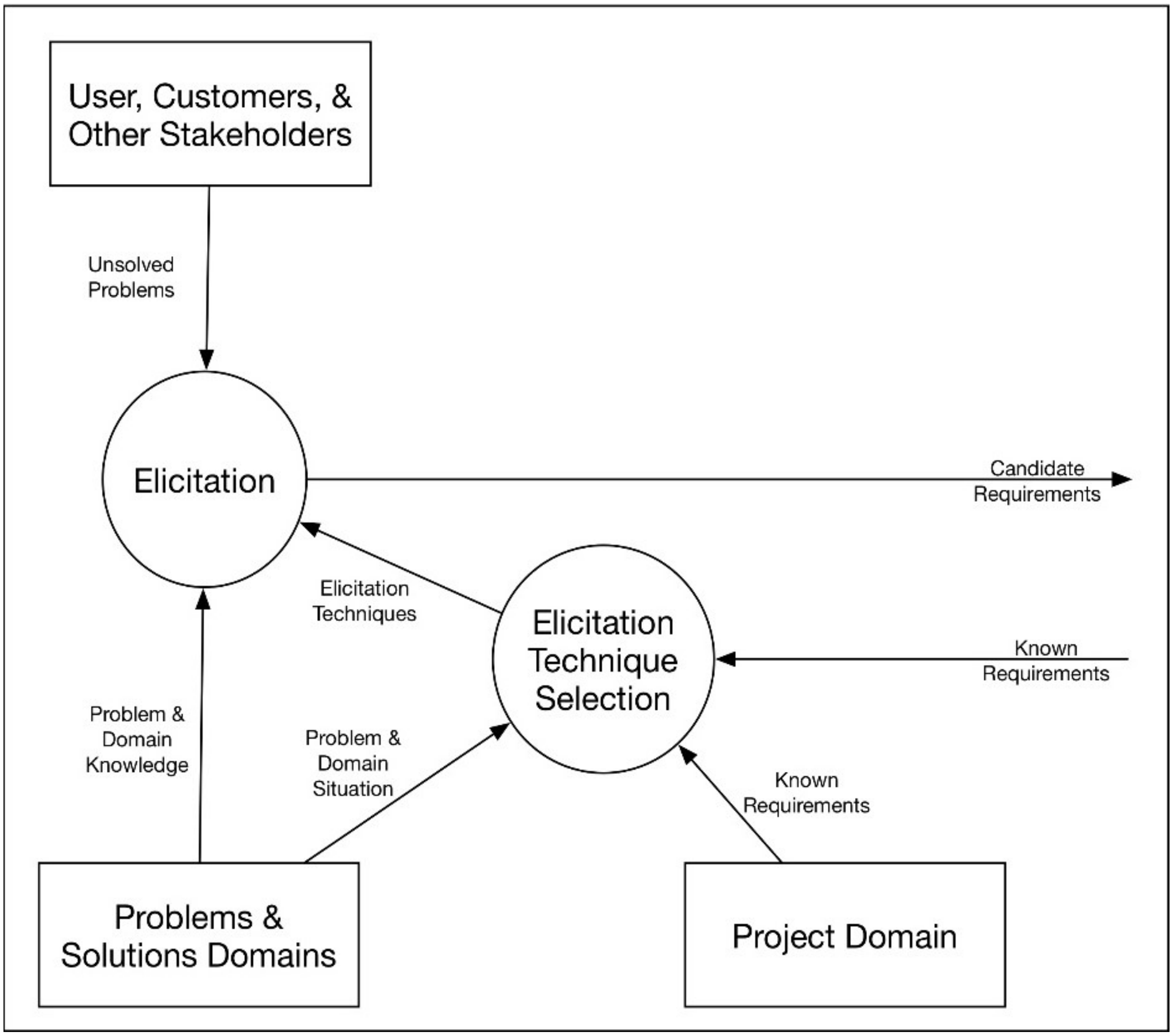

Figure 2-4: **Elicitation activities (Hickey & Davis, 2003:5)**

2.1.4.1.4 COMMUNICATION WITHIN THE RE ELICITATION PROCESS

The two models provided in the previous section both indicated communication as an important part of the RE elicitation process. Hickey and Davis (2003:4) adapted an illustration provided by Dean *et al*. (1997:188) to produce the illustration in Figure 2-5. This illustration depicts the communication channels within the RE elicitation process.

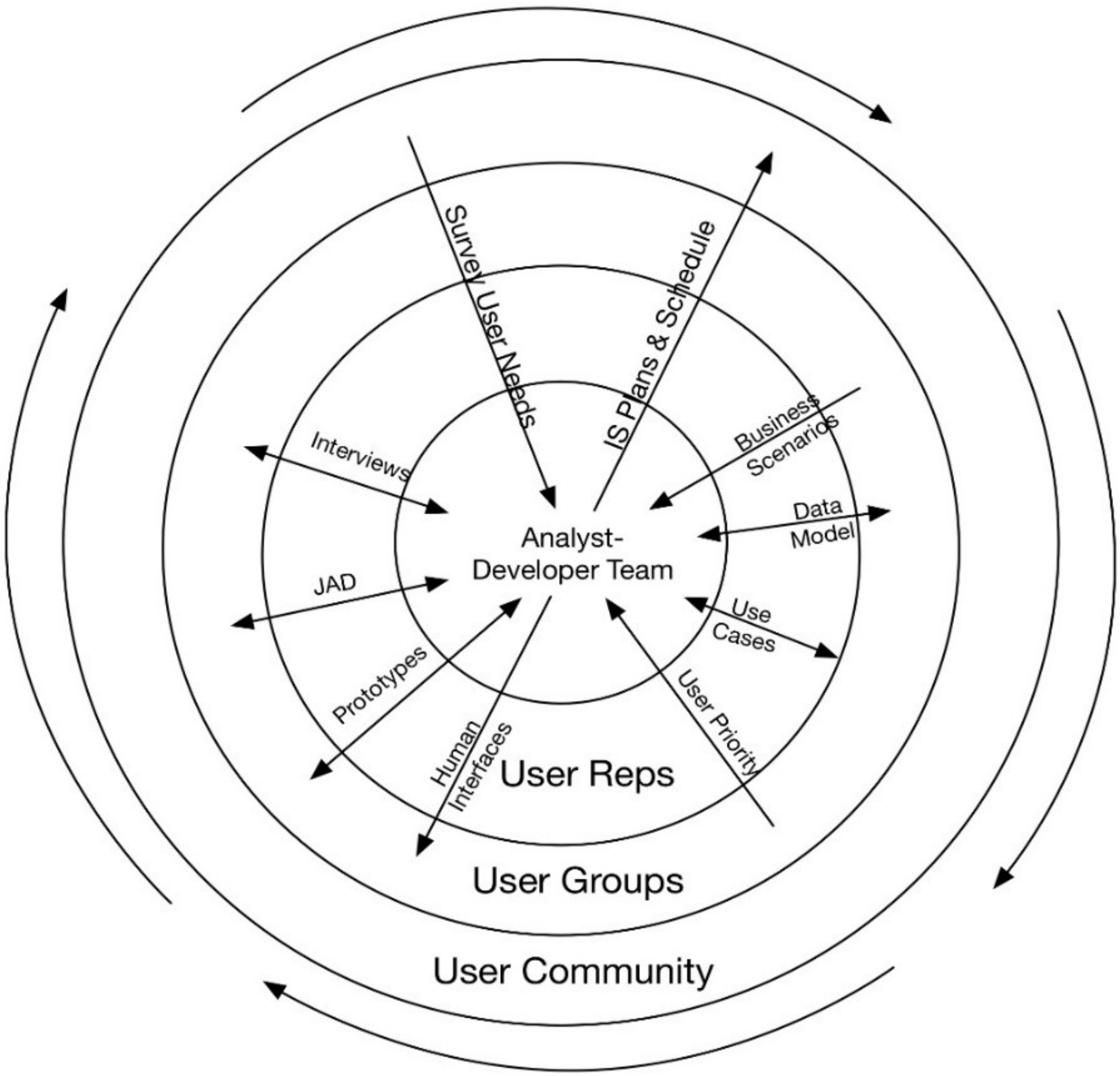

Figure 2-5: Communication channels within RE process (Hickey & Davis, 2003:4)

The outermost part of Figure 2-5 indicates the completion of a step in an elicitation method. Dean *et al.* (1997:187) state that each path around the circle should be predetermined but Hickey and Davis (2003:4) explain that each of these paths should not be predetermined because the components should depend on current knowledge of requirements as well as the different domains (solution, problem, and project) as previously mentioned. Although Dean *et al.*

(1997:187) and Hickey and Davis (2003:4) have different views on the components used, both state that teamwork is of great importance during the development and therefore communication should be a high priority.

Coughlan and Macredie (2002:47) state that RE process contains various communication activities and that these are performed by various individuals with different knowledge, skill levels, and background. These communication activities are all carried out in order to reach a specific goal, which is to understand a problem and ultimately find its solution. Furthermore, Coughlan and Macredie (2002:48) describe two different approaches to system design. These include the human-centred approach and the product-centred approach. Each of these approaches will have different viewpoints on communication during development. This is shown in a comparison table provided by Couchlan and Macrede (2002:48). Table 2-5 indicates the differences in assumptions for the two approaches mentioned.

Table 2-5: Product and human approaches (Couchlan & Macrede, 2002:48)

Assumption	**Product**	**Human**
Goals	Completed system	Customer satisfaction
Derivation of specification	Given/extracted by the customer/user	User-designer collaboration
Nature of user-designer communication	Contractual	Continual

The first assumption, the goals, indicates what communication activities will be used in order to achieve them. The product-centred approach will rely on communication activities in order to complete the system, with less emphasis on stakeholders, while the human-centred approach will consist mostly of communication activities that will promote customer satisfaction. The derivation of the specifications during a product-centred approach is achieved by getting or extracting the requirements from the user. Human-centred approaches rely more on collaboration between the user and the designer in order to obtain specification. This will result in a more continuous form of communication while product-centred approaches deliver a specification list similar to a contract, hence the contractual form of communication (Coughlan and Macredie (2002:47). Furthermore, Coughlan and Macredie (2002:47), describe how most of the core of the requirements needed in Requirements Engineering can be found in the social worlds of the stakeholders. This statement implies that requirements cannot be finalised at the beginning of development (as with the use of product-centred approach) and that they will change (Coughlan & Macredie, 2002:47). Ultimately, requirements are derived through successful communication and the success of the communication will rely on the level of understanding between the stakeholders, development team all other involved parties.

2.1.4.1.5 PROBLEMS WITH THE RE ELICITATION PROCESS

The RE elicitation process allows the user/developer/stakeholder to use a wide range of techniques in order to complete the process. Although there are various techniques available and different methods to implement them, problems still arise in the RE elicitation phase. The problems that were mentioned by Lachana (2012:2999) are as follows:

- The process of requirements elicitation is sometimes seen as straightforward but it is in fact very complex. The main reason contributing to this complexity is that requirements change during the development phase. A project also consists of many stakeholders, which can lead to communication problems.

- As mentioned before, not every elicitation technique will work with every project. Thus different techniques should be used for different projects (Nuseibeh & Easterbrook, 2000:39).

- Certain techniques will require more knowledge to implement and in some cases extra guidelines are also needed (Nuseibeh & Easterbrook, 2000:39).

- Techniques such as prototyping require more resources and the number of prototypes that can be developed for a system is sometimes limited (Sutcliffe & Sawyer, 2013:92). Thus certain techniques will take longer and cost more to implement than others in order to obtain the desired results.

- Lachana (2012:2999) states that its time-consuming nature is the main problem with requirements elicitation.

In addition to the above problems, and as mentioned in the previous section, communication is a very important part of the elicitation process. Communication problems are also very common during the elicitation process (Coughlan & Macredie, 2002:47). Incomplete requirements documentation is a direct result of poor communication. This in turn will result in further problems with communication as the correct requirements cannot be communicated to the next stage of the development process. Furthermore, Couchlan and Macredie (2002:47) and Lachana

(2012:2999) mention that problems within the elicitation technique can be divided into three categories, which include the following:

- **Scope**: This category refers to the problems related to the scope of the project. Not enough knowledge or insufficient understanding of the scope give rise to requirements elicitation issues in this category.
- **Understanding**: This includes problems with communication as well as general problems that relate to the understanding of the problem and the requirements.
- **Changes**: This area includes all the problems and issues related to changes in the requirements throughout the development of the system/software.

Communication is evident in all these categories, especially in understanding. In the previous section it was mentioned that the main goal of communication in requirements elicitation is to be able to understand a problem. Failing to communicate during this process will result in the needs of the user not being satisfied (Couchlan & Macredie, 2002:47).

The rapidly changing environment of businesses and of information technology results in companies having a shorter time to deliver products. Shorter developing life cycles result in problems with requirement elicitation because there is less time to extract requirements sufficiently (Lachana, 2012:2999). The models provided in this section were introduced in order to resolve some of the problems mentioned here. Although these models are designed to resolve the issues, not all issues are resolved and persist in the development of projects today. Identifying and analysing these issues can indicate critical components that must addressed in this study.

2.1.4.2 REQUIREMENTS ANALYSIS

The next step in the RE process is requirements analysis. Simply put, this step will take the requirements gathered during the requirements elicitation process and refine them further. All gathered requirements will be put together in order to extract more detailed requirements (Westfall, 2006:11). Somerville (2005:16) adds to this by explaining that during this phase the requirements are studied in order to understand them, identify overlaps within the requirements, and identify any conflict that may arise as a result of the requirements.

In order to perform the requirements analysis process, Nuseibeh and Easterbrook (2000:40) suggest that models should be created from the elicited requirements and then analysed. There are various models that can be used in order to analyse the requirements. Table 2-6 indicates the various modelling techniques that can be used (Nuseibeh & Easterbrook 2000:40).

Table 2-6: 6 Requirements analysis modelling approaches (Nuseibeh & Easterbrook 2000:40)

Model	Description
Enterprise modelling	This type of modelling requires the organisation and its structures to be understood. These structures also relate to rules that will affect the product being developed, the individuals within the organisation, and the data that is needed, used, and generated by the organisation. This type of modelling is often employed to identify the purpose of the system.
Data modelling	Data modelling is often used in organisations where large volumes of information are used or worked with. As with enterprise modelling, there is something that needs to be understood, and in this case it is the data. The data needs to be understood as well as managed. The use of data modelling will help to identify how the data will be represented by the system being developed.
Behavioural modelling	The function and behaviour of current systems and stakeholders are an important factor when looking at current as well as future systems. During this type of modelling it may be necessary to create three models. The first model will serve to illustrate the current functions of the system, the second model will illustrate the functionality of the system, and the last model will be used to illustrate the functions of the desired system. It is important to distinguish between these models in order to select the correct model for the correct analysis.
Domain modelling	In the previous sections different domains were mentioned. Domain modelling can be used to understand the environment in which the system being developed will function. The use of domain modelling will provide advantages such as a description of what is known about a certain domain and will provide information about what requirements can be reused within the certain domain.

The use of modelling will thus promote the analysis process. The analysis will identify whether or not the requirements are consistent. Nuseibeh and Easterbrook (2000:40) explain that, because of these models, a tool knows as Software Code Reduction (SCR) can be used for analysis (Heitmeyer *et al.*, 1996:232). SRC is an automated tool that will verify whether the models mentioned above are consistent and complete or not. Requirements analysis can also be carried out by employing other methods, such as prototyping, requirements animation, analysing feasibility, etc., and will depend on the information gathered from the elicitation process (Nuseibeh & Easterbrook 2000:40; Westfall, 2006:11)

The information gathered from the modelling and analysis can sometimes result in another iteration of the elicitation process as new information is gathered. Missing requirements, clarity on requirements, and conflict between requirements are identified and resolved during this process (Westfall, 2006:11).

2.1.5 CONCLUSION

This part of the literature review focused on RE. The first part of the discussion focused on defining RE closely. The literature showed that RE is not only a very important field, but also a complex process. Section 2.1.3 looked at the different types of requirements of the RE process, and the last part consisted of the different phases. The next part of the literature study, Section 2.2, will focus on the goal oriented requirements engineering (GORE).

2.2 GOAL ORIENTED REQUIREMENTS ENGINEERING

2.2.1 INTRODUCTION

Chapter 2.1 covered the RE process. The various RE models discussed use the term *goals* in some context and accordingly this section will look at the role of goals throughout the RE process. The use of goals is recognised as one of the most important components of the requirements engineering (RE) process (Van Lamsweerde, 2001:249). The requirements are gathered during the RE process in terms of goals and this process is known as goal oriented requirements engineering (GORE). Regev and Wegmann (2005:353) state that research carried out on RE with the focus on goals revealed that they provide a rationale for the development of systems. Thus GORE is used to elicit, organise, and manage the goals (Sen & Hemachndran, 2010:16). These goals are used in their turn to organise, manage, and drive the requirements elicitation process.

This section will provide a literature review of GORE which will include the following topics as focus points. The first part will discuss what GORE is and provide the definition of GORE. Secondly, we will take a look at the different components that constitute GORE. Finally, the different GORE methods will be provided and discussed.

2.2.2 WHAT IS GORE?

The previous section (Chapter 2.1) discussed RE and the importance of the RE process during systems development. Nuseibeh and Easterbrook (2000:35) describe real-world goals as one of the focus points during RE. In addition to these real-world goals (the "*what*" and "*why*"), Ross and Scoman (1977:6) provides the following definition.

> *"Requirements definition is a careful assessment of the needs that a system is to fulfil. It must say why a system is needed, based on current or foreseen conditions, which may be internal operations or an external market. It must say what system feature will serve and satisfy this context. And it must say how the system is constructed."*

A more recent definition is provided by Van Lamsweerde (2004:4), as follows.

> *"Goal-oriented requirements engineering (GORE) is concerned with the use of goals for eliciting, elaborating, structuring, specifying, analysing, negotiating, documenting, and modifying requirements."*

This definition contributes to the first definition in the sense that GORE is like normal RE but with the exception of the use of goals. In order to fully understand GORE, the term it stands for needs to be examined more closely. The first part discusses what these goals are. Second we will examine why these goals are needed. The last part will identify the origins of the goals (Sen & Hemachndran, 2010:17; Van Lamsweerde, 2001:250).

2.2.2.1 THE GOALS

The goals in GORE are defined in various ways in the literature. The first definition is provided by Sen and Hemachandran (2010:17).

> *"A goal is an objective that the system under consideration should achieve."*

The second definition is provided by Van Lamsweerde (2004:5).

> *“Goals are perspective statements of intent whose satisfaction requires the cooperation of agents (or active components) in the software and its environments.”*

These two definitions both mention that the goals are the reason for or the purpose of the system is being developed. The system under development must provide a certain function or achieve a certain objective which ultimately constitutes the goals of the system. Regev and Wegmann (2005:354) list the following reasons why focusing on goals during the RE process is important.

- The use of goals provides a higher level of view in terms of requirements in comparison with traditional requirements engineering;
- The use of goals provides better stability in comparison with the requirements that implement them;
- Goals promote the ability to choose between alternative requirements;
- There is better verification of whether or not the requirements are complete when using goals; and
- Goals provide traceability from the organisational context to the requirements.

The system under development and its environment are seen as a collection of active components called agents (Lapouchnian, 2005:5). The requirements in GORE are seen as a goal which must be achieved by one of the agents. The agent can be a person, another software system, etc. Thus there are responsibilities added to each of the agents. Furthermore, there can also be assumptions which cannot be satisfied by the new system but rather by the environment in which the new system will function. Thus, GORE focusses on goals with the responsibility to satisfy the goals placed on the agents.

Van Lamsweerde (2001:250) adds to the point about how goals provide a higher-level view of requirements by explaining that goals can be formulated at different levels of abstraction, which can include:

- ***High level -*** This level can include strategic concerns. The example provided by Van Lamsweerde (2001:250) explains this in terms of a railway system that would like to serve more passengers.
- ***Low level -*** This level can include technical concerns. The example provided by Van Lamsweerde (2001:250) explains this in terms of the acceleration command the train driver executes. This acceleration must occur when the command is executed.

It is important to note that the goals can be used in order to identify requirements in the high-level category, the low-level category, and everywhere in between. Goals are thus not limited to strategic and technical concerns. To further explain the different levels and types of goals, Maté *et al.* (2014:107) identified the following:

- ***Strategic goals:*** These goals represent the desire to change the current situation to that of the future. The future, in this description, is used here to indicate the desired outcome of the system under development. These goals are also related to the improvement of the business process and the main objectives of that process. In addition, an objective must be met when trying to satisfy the goals.

- ***Decision goals:*** In order to identify these goals, the following question must be answered:

  > "*How can a strategic goal be achieved?*" (Maté *et al*., 2014:107)

  By answering this question, the strategic goals will be transformed into actions that can be executed. These goals use information to provide actions or decisions that can be carried out to confer some benefit. Decision goals can be described as some kind of objective. By using decision goals, the strategic goals can be achieved, hence the importance and benefit of using these goals.

- ***Information goals:*** These goals are used to identify the information required, as mentioned above. In order to obtain them, the following question is posed.

  > *"How can decision goals be achieved in terms of information required?"* (Maté *et al*., 2014:107)

  The information goals will specify what information is needed and are mostly identified by some sort of analysis. The outcome of these goals will provide the information necessary to satisfy the decision goals.

Van Lamsweerde (2001:250) furthermore distinguishes between requirements and assumptions when working with goals.

- ***Requirement -*** a goal will become a requirement when the responsibility of satisfying that goal is an agent within the system under development.

- ***Assumption -*** a goal will become an assumption when the responsibility of satisfying that goal is an agent within the environment in which the system under development will function.

Furthermore, these assumptions cannot be satisfied or controlled by the system under development, but can be satisfied by components such as the organisation culture, the law of physics, etc.

Lastly, Regev and Wegman (2005:356) list the following different types of goals which may be identified during the GORE process.

- ***Achievement Goal:*** This is defined by Antón (1997:84) as goals that "*are objectives of an enterprise system*" and a goal which "*is satisfied when the target condition is attained*". Van Lamsweerde (2001:252) describes these goals as those that result in a certain system behaviour. This implies that they possess a property which requires them to be satisfied in the future.
- ***Maintenance Goal:*** Antón (1997:84) defines these goals (with regard to Goal-Based Requirements Analysis Method (GBRAM) which will be discussed later) as follows.

  > *"Maintenance goals are those goals which are satisfied while their target condition remains constant or true. They tend to be operationalized as actions or constraints that prevent certain states from being reached. In general, maintenance goals map to non-functional requirements."*

  Van Lamsweerde (2001:252) also mentions restrictions when describing these goals. This will restrict some of the new system's behaviour, in the sense that in order to satisfy these goals, a certain property must be permanently satisfied in every future state of the new system. However, these goals can still be achieved if another of their properties is met and overrides the previous mentioned statement.

- ***Soft-goals:*** Regev & Wegmann (2005:356) defines soft-goals as follows.

  > "*A condition or state of affairs in the world that the actor would like to achieve, but unlike in the concept of (hard) goal, there are no clear-cut criteria for whether the condition is achieved, and it is up to subjective judgement and interpretation of the developer to judge whether a particular state of affairs in fact achieves sufficiently the stated soft-goal.*"

  Van Lamsweerde (2001:252) states that these goals are very useful and that, just as above, their satisfaction is not determined in a definite manner. Their usefulness lies in the fact that they can be compared with alternative goal refinements and one that is best suited to the soft-goal can be chosen

This section, Section 2.2.2.1, covered precisely what the goals in GORE are. This indicated that there are numerous goals such as, high and low level, achievement, maintenance, and soft goals, that can be elicited, each with its own characteristics that will help to identify certain requirements. The next part, Section 2.2.2.2, will look at why these goals are needed.

2.2.2.2 WHY USE GOALS?

The use of goals in the RE process offers various advantages. In order to understand why goals are important, these advantages will be discussed. Lapouchnian (2005:5) adapted the following list of benefits when using goals from Van Lamsweerde (2001:250):

- The first advantage mentioned is that when goals are used in the RE process the engineering process stretches further than the system under development, and includes the environment in which this system will function. In addition to the normal requirements of the system, the domain properties and expectations of the environment is also captured. Lapouchnian (2005:5) describes this as one of the main advantages of GORE, which is the support for early requirements analysis.

- The use of goals will also provide criteria for ensuring completeness of the requirements. Lapouchnian (2005:5) and Van Lamsweerde (2001:250) explain that a specification is complete when the specification, in terms of a set of goals, can be used to satisfy all the goals in the mentioned set of goals. The properties of the domain must also be known for the requirement to be complete.

- Goals provide criteria for requirements relevance. This implies that, as in the previous point, the requirement, in terms of a set of goals, can be used to satisfy at least one of the goals in the set of goals. Lapouchnian (2005:5) mentioned that when using goal models, it is easy to see whether or not a goal can contribute to a higher-level stakeholder goal.

- It is important to explain the requirements to the stakeholders. The use of goals will provide a goal refinement tree. This tree will provide traceability links from the higher-level objectives down to the more technical level. Breaking the requirements down into these different levels will make them easier to explain to stakeholders. Furthermore, because decision makers are involved in the validation of choices being made in terms of alternatives, better decisions may be made and different alternatives suggested.

- Goals will also provide a natural mechanism for structuring goals. This in turn will improve the readability of more complex requirements documents.

- During the RE process, engineers face the problem of dealing with different alternatives. The use of alternative goal refinement has been proved to provide the correct level of abstraction. This will help the decision makers to identify other alternatives that may have been overlooked and will assist in the decision making process because more alternatives are available (Van Lamsweerde, 2001:250). The use of quantitative and qualitative analysis on these alternatives is also enabled, which will further help the decision makers.

- Management of conflicts due to multiple viewpoints is also a major concern in the RE process. Van Lamsweerde *et al.* (1998:926) state that by using goals the root of the conflict can be more easily identified and more easily resolved.

- An important aspect in the management of requirements evolution is the separation of the stable information from the more volatile information. Van Lamsweerde (2001:250) explains that a certain specification will satisfy a certain goal, and that this requirement is likely to evolve or change in order to satisfy the same goal in some other way. Thus the requirement is more likely to change than the goal itself. This implies that the higher the level of the goal, the more stable the requirement will be.

The above advantages as well as the points mentioned by Regev and Wegmann (2005:354) indicate that the use of goals can be very beneficial when developing a new system. The next part of the discussion will describe where these goals originate.

2.2.2.3 ORIGIN OF GOALS

The above two sections (Section 2.2.2.1 and Section 2.2.2.2) describe what goals are and why they are used. This section will focus on where these goals come from. Van Lamsweerde (2001:250) mentions how these goals can sometimes be explicitly stated by the stakeholders or can be gathered from information such as preliminary material that is available to the engineers. The first source of goals, according to Van Lamsweerde (2001:250), is analysis of the current system. This will provide a good description of problems and shortages that must be addressed in the new system. The elicitation techniques mentioned earlier in connection with the elicitation of requirements in in RE can also be used in order to elicit goals in GORE. Van Lamsweerde (2001:250) states that, from experience, using keywords when analysing current documents will also help to identify goals.

The next part of the process can be undertaken when the preliminary set of goals has been identified. The next step will be to analyse these goals. Through refinement and abstraction (as mentioned above) new goals can be elicited. This process is completed by the stakeholders; and by asking certain types of questions (as with traditional RE) such as *what?* and *why?* more goals can be identified.

2.2.2.4 CONCLUSION

To conclude, GORE can be defined as follows: GORE looks at the new system being developed with the environment in which it will function, as a whole rather than individual components. Goals are identified and used in order to extract requirements. Certain agents are assigned to certain goals and each of these agents is responsible for these goals. Thus the main focus point of GORE is to identify goals and let these goals be satisfied through agents, with the responsibility of completion resting on the specific agent.

2.2.3 THE GORE PROCESS

GORE, as in traditional RE, is a process that must be carried out. In this process there are various phases that must be carried out. The next part will discuss what is entailed in the GORE process. It is very similar to that of traditional RE, with the exception of goals and agents. Figure 2-6 depicts the tasks (indicated in the circles) with the activities (indicated in the rectangles) for each task (Vinay *et al*., 2011:2). The first task will be to elicit the goals. This can be done by employing the different techniques indicated in the box opposite the circle in Figure 2-6. The following tasks will be goal analysis, goal refinement and goal validation. The last three tasks are completed when the subtasks opposite each circle are completed. The double-headed arrows indicate that there can be movement from and to each task, meaning that if goal analysis, for example, should indicate that the elicitation is incomplete, the user can go back to the previous task, etc.

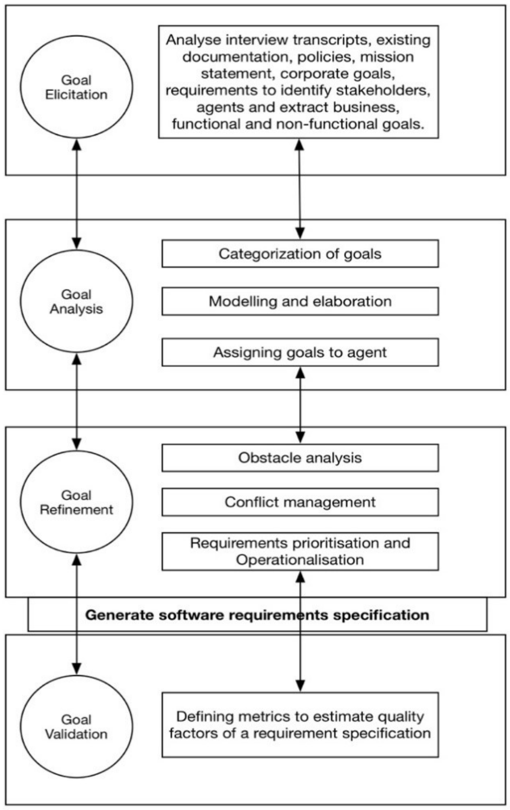

Figure 2-6: GORE Activities (Vinay *et al*., 2011:2)

Aljahdali *et al*. (2011:331) list the following activities as the main activities that are carried out during GORE:

- Elicitation;
- Analysis;
- Specification; and
- Requirement Management.

These activities differ from those in Figure 2-6 as they require specification and requirements management instead of goal refinement and goal validation. Although there are differences, requirements management can be seen in goal refinement in Figure 2-6. Requirements specification is also evident in goal validation in Figure 2-6. The above list will be used to discuss the GORE process in the next sections. Each of these activities has certain sub-activities that are also carried out. To further clarify the GORE process, these activities will be discussed.

2.2.3.1 ELICITATION

The elicitation of goals is not an easy task, as with traditional RE. The goals can be explicitly stated by the stakeholders or gathered from documentation or other sources, or they can be implicit. Goals that are implicit are the reason for the elicitation process, which will help to identify these goals (Lapouchnian, 2005:13). These goals may originate from inspection of the current system as well as the organisation and current documentation, conducting interviews, and other activities (as mentioned in Section 2.2.2). Van Lamsweerde (2001:250) suggest that identifying and solving problems and issues with the current system and organisation is a good starting point for eliciting goals.

Aljahdali *et al*. (2011:331) list domain analysis and requirement and assumption identification as two activities carried out during the elicitation phase. These activities, with the following, can be evident in the elicitation process:

- Identifying and understanding the problems of the stakeholders. When their problems have been fully understood the software engineers can start to find appropriate ways of neutralizing them. These negating strategies can eventually evolve into requirements (Regev & Wegman, 2005:357)

- Goals can be extracted from current information such as: transcripts of interviews, policies, mission statements, the goals of the organisation/enterprise, work-flow diagrams, and scenarios written with the stakeholders (Rolland, 1998:1055).

- As previously mentioned, asking the questions “*why?*” and “*how?*”, can help to elicit goals. Asking these questions of already established goals can lead to goals evolving and the identification of more goals (Van Lamsweerde, 2001:251).

- Alternative goals can be identified by asking “*how else?*” (Van Lamsweerde, 2001:251).

The preliminary goals are also a good starting point for further goal elicitation. It is important to note that this is an ongoing process and that goals will evolve and be identified throughout the development process (Regev & Wegmann, 2005:357). Some of the GORE methods, such as GBRAM (this together with other methods will be explained later on at Section 2.2.4.1), use a set of heuristics in order to elicit more goals from the mentioned preliminary goals. The following are what the heuristics suggest when GBRAM is used (Antón, 1997:135; Regev & Wegmann, 2005:357):

- Using action words that describe a certain state more clearly to identify goals. States can include achievements, maintenance, upgrade, etc. For example, the state “maintenance” can be described by keywords such as monitor or track to to elicit new goals.

- Identifying what goals are achieved by certain statements and what goals will not be achieved by certain statements is also important during this process.

- Identifying why a specific goal needs to be achieved or maintained will also help to identify more goals or clarify the current goal.

- Analysing what happens before a certain goal must be achieved, and what is supposed to happen after the goal is achieved is also important.

- Identifying the constraints or obstacles of certain goals can help to identify more goals.

Liaskos *et al.* (2005:13) suggest that goals can be elicited from configuration menus in the current software. Goals can be identified by creating a goal model that represents high-level user goals in the configurations menu. The goals are refined in order to create the high-level goals. The example used by Liaskos *et al.* (2005:13) explains this concept in the form of the “*options”* or “*preference”* menu within the software. For each of these configurations or options, questions are asked to identify whether or not these items are a result of one of the functional user goals or if it will contribute to a soft-goal (as described in Section 2.2.2.1). These soft-goals can relate to each other through the use of contribution links and can also result in the identification of more abstract soft-goals. This whole process will result in a goal model which can be used to identify what configurations will be used in the new system (Lapouchnian, 2005:14).

The elicitation process is thus a very important part of GORE, just as in traditional RE. The activities and methods discussed above provide various ways in which goals can be elicited. These activities and tasks also correspond to the activities illustrated in Figure 2-6. Lastly, each of the different methods, such as GBRAM, uses different methods for eliciting goals. These methods will be discussed in Section 2.2.4.1.

2.2.3.2 ANALYSIS

The analysis of goals is the activity step in the GORE process. Just as with the elicitation of goals, the analysis also consists of various steps that can be carried out during this process. Venay *et al*. (2011:2) suggest that the following activities should form part of the analysis:

- Categorisation of goals;

- Modelling and elaboration; and
- Assigning goals to agent.

Aljahdali *et al*. (2011:331) list the following activities, in addition to those above, which should form part of the analysis process when using GORE:

- Classifying goals;
- Conflict identification and resolution; and
- Prioritisation.

2.2.3.2.1 CATEGORISATION AND CLASSIFICATION OF GOALS

The first activities of discussion, the categorisation and classification of the goals, are given by Venay *et al.* (2011:2) and Aljahdali *et al.* (2011:331). To further classify goals (from Section 2.2.2.1), the following lists different types of goal classification, their attributes and links to other goals within the requirements model:

- **Goal types and taxonomies**: The first classification and categorisation of goals are done according to the type of goal. As already mentioned, there are various types of goals, such as functional goals, non-functional goals which also include accuracy goals, performance goals, soft-goals, hard goals, achievement goals, and maintenance goals.

- **Goal attributes:** Goals can also be categorised according to certain attributes. This can include the name or their specification. The priority of a goal is also an important attribute of a goal that can help with this categorisation process (Dardenne *et al.*, 1993:24).

- **Goal links:** The last type of categorisation provided by Van Lamsweerde (2001:252) is t according to links. These links can be between different goals or between different elements within the requirements model. Links between goals can include the following types of links (Van Lamsweerde. 2001:252):

    1. The first type of link is used to show whether or not the different goals support each other negatively or positively.
    2. A link can indicate conflict between goals. This link will indicate whether or not the one goal will prevent the other from being satisfied in one way or another.
    3. Links can also be used in order to identify sub goals. This is known as satisficing where sub goals are identified by analysing the links. A sub goal can thus help to satisfy the

parent goal partially, regardless of the other sub goals (if there are any), and can be either positive of negative.

In addition to goals being linked to each other, they can also be linked to the different elements of the requirements model.

- Links can be used to link operations to goals. This can be in the form of the different actions that should be carried out before, during, and after a certain operation in order to ensure goal satisfaction (Antón *et al*., 1994:94; Antón & Potts, 1998:165; Kaindl, 2000:538).

- There can be contribution links which will identify the effect, whether positive or negative, of certain requirements for goals.

- Another link that is described by Van Lamsweerde (2001:252) occurs between goals and scenarios. Scenarios, as described by Van Lamsweerde (2001:252), are "*concrete, narrative, procedural, declarative, and make intended properties implicit*" while goals are "*abstract, declarative, and make intended properties explicit*". Thus, Van Lamsweerde (2001:252) explains, because of these properties, scenarios and goals complement each other well, especially during the process of requirements elicitation and validation.

- Finally, links can be used to relate goal models to object models as certain goals can refer to certain objects such as agents (Dardenne *et al*., 1993:24; Van Lamsweerde, 2000a:11). The links can be used to indicate relationships between goals and the objects. Furthermore, the links can also indicate dependency where an agent is dependent on the completion of another goal in order to satisfy a current goal (Yu, 1997:229).

2.2.3.2.2 MODELLING AND REFINEMENT OF GOALS

Kavakli (2002:240) states that goal analysis is a phase that is evident in the other activities of GORE, such as the elicitation and specification steps. To illustrate this, Kavakli (2002:240) has provided Table 2-7 below.

Table 2-7: The role goal analysis (Kavakli, 2002:240)

RE Activity	**Goal analysis contribution**
Requirements elicitation	Understanding the current organisational situation.

	Understanding the need to change.
Requirements specification	Relating business goals to functional and non-functional system components.
Validation	Validating system specifications against stakeholders' goals.

Although Vinay *et al*. (2011:2) illustrated in Figure 2-6 that the goal refinement process should be seen as a different process on its own, Aljahdali *et al*. (2011:311) and Lapouchnian (2005:14) suggest that these two processes (goal analysis and goal refinement) should go hand in hand. Lapouchnian (2005:14) describes the process of goal refinement as the core activity during GORE and that each different GORE method will provide its own method of refinement, as well as formal and semi-formal analysis methods.

Partial goal satisfaction is another aspect that emerged in the literature (Lapouchnian, 2005:14). Partial goal satisfaction is a phenomenon that occurs when certain goals do not need to be satisfied completely. The statement below explains this more clearly (Lapouchnian, 2005:14):

> "*This goal needs to be satisfied in at least 80% of the cases.*"

In order to handle these cases, various methods were developed (which will be discussed in Section 2.2.4.1), each with different analysis and refinement methods. The techniques provided by Letier and Van Lamsweerde (2002a:83) and Darimont and Van Lamsweerde (1996:179) cater for the satisfaction of goals where goals need to be satisfied completely. In addition to these methods Letier and Van Lamsweerde (2004:53) suggested another method which could cater for these partial goals. This method specifies to what degree the goal must be fulfilled. The method also determines the impact that various system goals may have if they were partial goals. The degree to which the goal must be satisfied can thus influence the manner in which the refinement of the goals can occur.

Another aspect of the refinement process is to analyse obstacles that occur when dealing with these goals. Lapouchnian (2005:16) originally suggested identifying the idea behind obstacles by asking questions such as "*Can this goal be obstructed, and if so, when?*" The answer to this questions leads to the identification of certain heuristics that could help in resolving these obstacles. Some of these heuristics include identifying probable failures and mistakes whether confusion exists about certain objects and resources contention. Van Lamsweerde and Letier (2004:337) describe the following reasons as advantages of obstacle analysis:

> "*Obstacle analysis helps producing much more robust systems by systematically generating (a) potential ways in which the system might fail to meet its goals and (b) alternative ways of resolving such problems early enough during the requirements elaboration and negotiation phase.*"

2.2.3.2.3 AGENTS AND THE ASSIGNMENT OF GOALS

The next component of the analysis phase involves assigning agents to goals (Vinay *et al.*, 2011:2). This is not a simple task and thus various methods of GORE such as GBRAM and Knowledge Acquisition in autOmated Specification (KAOS) are required to provide different methods of assigning agents to goals. Lapouchnian (2005:17) mentions that most of these models see the system under development as well as the environment in which this new system will function as one set of agents. This set is handled objectively by the software engineer, decomposed to assignable goals, and assigned to an agent. In contrast to this, it may be necessary to handle this set of agents subjectively. This implies that instead of assigning goals to agents from the engineer's point of view, the viewpoint of the agent who is responsible for the goal is brought into consideration (Lapouchnian, 2005:17). According to Lapouchnian (2005:17) the use of a subjective point of view can be positive in the following instances:

- In the case of a system that is very complex in terms of social aspects, and in which the human agents have different interest; and
- In the case of the analysis of security requirements, for which there needs to be a motivation and actions defined for hostile agents.

Lapouchnian (2005:17) furthermore mentions that there are problems associated with the above method whereby the system and environment are seen as a composite component.

- The first problem identified is that, when using such a method, it is implied that the goals and all the alternatives that are available in the goal model have already been chosen before the agents are assigned. This will result in all the other alternatives being lost and the agents not knowing of these alternatives.
- The loss of the alternatives will result in only the chosen alternatives being used. Lapouchnian (2005:17) states that this will result in the system being fragile.

There are, however, other methods, such as TROPOS, which assign goals and agents throughout the development process, and which result in a more flexible system.

2.2.3.2.4 CONFLICT HANDLING OF GOALS

The final point of discussion for the analysis phase during GORE will be the conflict handling and resolution of goals. Lapouchnian (2005:20) mentions that there are various stakeholders such as the clients, developers, and users, who have their own needs, objects, skills, etc. Because of these components conflict between these stakeholders is bound to occur. These conflicts need to be addressed as soon as they arise and be resolved effectively to ensure a requirements specification that is complete (Lapouchnian 2005:20). The approach suggested by Boehm *et al*. (1995:243) is goal based and focuses on renegotiation in order to resolve these conflicts. This approach suggests a model that can be used to identify all the stakeholders with their preferred goals. The step is to identify all the conflicts that can occur between the goals, as well as the risks involved. These conflicts are resolved by negotiation. This approach, according to Boehm *et al.* (1995:243), is an iterative approach, a normal characteristic of negotiation. In addition to the approach suggested by Boehm *et al*. (1995:243), Van Lamsweerde (2000b:978) suggests a more formal approach for conflict handling. This requires the different views of the stakeholders and goals to be captured during the analysis phase. Conflicts should then be identified and resolved accordingly. Furthermore, this approach also makes use of links, as mentioned previously. The agent and the goal/object are linked together as relationships. Views from the same agent are seen as a perspective and where overlapping views are causing problems, conflict resolution is needed.

2.2.3.3 SPECIFICATION

The next phase will be to formally create the requirements specification document. This is indicated in Figure 2-6 between goal refinement and goal validation. The position of this phase in Figure 2-6 indicates that it will be a deliverable when the previous three phases have been completed. As mentioned throughout the document, and especially in Section 2.2.3.1, new goals will be identified throughout the development process. This will result in the requirements specification being updated regularly in order to reflect the user requirements and to ensure that everyone involved in the development process is up to date with them. The requirements specification will serve as communication and thus needs to be up to date in order to prevent conflicts. This phase is not as elaborate as the previous two.

2.2.3.4 REQUIREMENT MANAGEMENT

The final phase in the GORE process is the management of requirements. Aljahdali *et al*. (2011:331) list the following activities as part of this phase:

- Requirement Change/ Evolution Management;
- Traceability;
- Conflict Management; and
- Measurement.

In short, this phase will cater for the changes that occur during development in terms of requirements. As already mentioned, the GORE process is iterative, thus this phase is needed to ensure that new requirements are identified during the other phases of the GORE process throughout the development life cycle. Note that the list provided by Aljahdali *et al*. (2011:331) contains components previously mentioned in other phases of GORE, such as conflict management. In addition to these activities, other model specific processes also exist. An example of this is the monitoring of requirements and resolution of any violations that may occur during runtime (Lapouchnian, 2005:25). The approach suggested by Feather *et al*. (1998:50) provided such monitoring for KAOS. This approach will identify certain requirements in the specification that might cause problems and assign a monitor to them to enable runtime monitoring.

2.2.3.4.1 IMPROVING THE REQUIREMENTS

Horkoff and Yu (2011:680) mention that there should also be requirements improvement. This process will occur after an initial set of requirements has been captured. The requirements can then be improved by checking inconsistencies and any error that may have occurred, as well as through considering critical properties. Model checking approaches can also be used to identify problems or conflicts that can occur because of requirements captured in goal models. In addition to requirements improvement, goal verification and goal validation can also form part of the requirements management phase (Van Lamsweerde. 2001:254).

- **Goal verification:** This process ensures that the requirements identified do indeed contain the goals that were identified. This process also checks if a set of requirements is sufficient to complete a set of goals. Goal verification can be done informally or formally, when the goal specifications and domain properties are formalised. This process can also be done during the analysis phase of GORE and is also applicable to requirements management as new requirements are also identified here.

- **Goal validation:** The validation of goals can also be carried out when focusing on requirement management. According to Van Lamsweerde (2001:254) scenarios can be used to validate the goals and the requirements. The use of scenarios can identify and detect deficiencies and can help to identify new goals and ensure that the requirements are complete.

2.2.3.5 CONCLUSION

The GORE process consists of various phases carried out during the development life cycle. The phases mentioned here are also evident in the traditional RE process. It is important to note that this whole process, just as with traditional RE, is iterative, and will be carried out throughout the development life cycle. There are other GORE methods that will implement these phases differently but still have a focus point, for example on links or attributes. The next part of the chapter will this discuss these methods, which result in a more complete understanding of the GORE process as a whole.

2.2.4 GORE METHODS

The final part of the discussion covers the different GORE methods/models. The next part will compare these models in relation to the GORE and RE process and will indicate different types of approaches and how to choose among them.

2.2.4.1 DIFFERENT GORE METHODS/MODELS

The literature provides various methods/models/techniques to implement GORE. Note that for this discussion the terms methods, models, and techniques are used as synonyms. In order to discuss these models, the name of each will be given with a short description in Table 2-8.

Table 2-8: Different GORE methods

Method/Technique/Model	Description
GBRAM (Lapouchnian, 2005:11)	Goal-Based Requirements Analysis Method. This method puts the emphasis on identifying and abstracting goals from various information sources. It assumes that there are no current documents on goals, and results in the use of diagrams, textual transcripts, etc. to identify the goals.
AGORA (Kaiya *et al*., 2002:12)	Attribute Goal Oriented Requirements Analysis method. This method allows for the use of goal properties and methods to solve conflicts. It can also be used to select alternatives and ensure the quality of the models.
DTEBS (De Landtsheer *et al*., 2003:104)	Deriving Tabular Event-Based Specifications. This method derives specifications by using other goal-oriented requirements models such as KAOS and SCR. This is an integration of frameworks and allows for the removal of semantic, structural and syntactic differences between KAOS and SCR. Thus this method combines normal goal oriented methods with tabular event-based models.
VVA (González-Biaxauli *et al*., 2004:198)	Visual Variability Analysis for goal models. This method is suitable for analysis and will also provide reports focused on variability of requirements which can be used to improve stakeholder satisfaction.
GOIG (Oshiro *et al*., 2003:363)	Goal-Oriented Idea Generation method. This method focuses on the elicitation phase. Different ideas are generated and grouped into goals by using heuristics.
DOSS (Letier & Van Lamsweerde, 2002b:119)	Deriving Operational Software Specifications. The focus point of this method is requirements specification. Semantics are defined for goal operationalisation based on pre, post, and trigger conditions. Taxonomy of goal patterns is also identified.

A-BT (Dardenne *et al*., 1993:3)	Agent-Based Tactics for goal-oriented requirements elaboration. The focus of this method is to propose certain tactics that can be used to resolve issues regarding goals that are not realised by the agents. Goals are unrealised when the responsible agent is unable to control the controlled variables.
GSTH (Regev & Wegmann, 2005:353)	General System Thinking Heuristics. This concept links the idea of regulation to GORE methods. It is used to elicit goals (achievement, maintenance, etc.) by defining a new, higher level of goals. Thus a new level of abstraction is created. This new level of goals, with a set of proposed heuristics, is used to elicit the goals.
Scalability Requirements (Duboc *et al*., 2008:247)	The literature describes how GORE can be applied to elicit the scalability of requirements. This method is used for real-world financial fraud detection systems.
NFR (Myopoulos *et al*., 1992:483)	This method is proposed by Myopoulos *et al*. (1992:483) and focuses on the modelling of the functional as well as the non-functional requirements. According to Lapouchnian (2005:7) this approach will help to systematically model but also refine the non-functional requirements. This will result in exposure of the positive and negative impacts of various alternatives on the requirements.
i* (this stands for i-Star)	This process is agent oriented. The application of this modelling framework can include requirements engineering, business process reengineering, organisational impact analysis, etc. This method is used in order to model activities that occur before requirements are formulated and can thus be used for early or late phase RE. The early phase will focus on what the system should be while the late phase will help to evaluate how the requirements meet the functional and non-functional requirements (Lapouchnian, 2005:8).

KAOS	This is a GORE approach with the addition of a rich set of various analysis techniques. This approach is described as Knowledge Acquisition in autOmated Specification (Dardenne *et al*., 1993:6) while Van Lamsweerde and Letier (2004:328) refer to it as "Keep All Objects Simple". Furthermore, this approach is defined as "*a multi paradigm framework that allows to combine different levels of expression and reasoning: semi-formal for modelling and structuring goals, qualitative for selection among alternatives, and formal, when needed, for more accurate reasoning*" (Lapouchnian, 2005:10)
TROPOS	This method was introduced by Castro *et al*. (2002:365) as a requirements-driven agent-oriented development methodology based on the i* modelling framework. This methodology will provide guidance for the development of agent based systems, from the early phase requirements analysis through to implementation (Lapouchnian, 2005:10).

Table 2-8 lists popular methods that were identified in the literature. It is important to note that each of these methods was introduced to cater for some sort of shortcoming or to extend a current method to manage other aspects that were not suitable. For example, TROPOS was introduced to help with the development of agent based systems while being based on the i* method. The focal point of the study is requirements elicitation and how these methods can be improved to improve the elicitation process. The first method that indicated a strong relationship to requirements elicitation was the GSTH (Regev & Wegmann, 2005:353). Although this is not a method but rather a concept, it can be used in other methods as well, as highlighted by Refev and Wegmann (2005:362) in the conclusion of their study. The underlying principle of this concept is the use of heuristics, of which the following can serve to identify goals (Regev & Wegmann, 2005:361):

- Using heuristics for the elicitation of maintenance goals: In order to use this method, each of the achievements goals must be analysed and one or more norms should be identified for each of the goals. The norms mentioned here are the ones the goals are intended to maintain. Norms can be identified as constraints and then be transformed into achievement goals. The manner in which the norms change over time and the change itself can be expressed in an achievement goal.

- Using heuristics for the elicitation of high-level goals. Regev and Wegmann (2005:361) suggest that the highest goal for an enterprise is the ability to survive. This in turn indicates that it is important to maintain the norms of the enterprise through the maintenance goals. An example of this is the following: An important norm is the maintenance of a good relationship with other enterprises. The maintenance goal can thus be to maintain a good relationship with other enterprises. A sub goal could be to maintain a relationship with customers, suppliers, employees, investors, etc. Thus the highest goals identified are the ones that are needed to maintain the norm from which the sub goals are then extracted.

The use of heuristics during the elicitation of goals can thus be seen as very useful. This process will help to identify goals that were not clear to the stakeholders and it can also be used with various GORE methods.

The different GORE methods also indicate the focus on different goals. Dardenne *et al*. (1993:21) indicate that the KOAS method focuses on non-operational goals. This a non-operational objective that must be achieved by the system. Antón (1997) describes the goals for GBRAM as targets for achievements. These achievements, which will be transformed into goals, will create a framework for the new system. Other methods can simply allow a goal to be something the stakeholder would want to achieve. Just as each of these methods can focus on goals, the types of goals can also be different. KOAS and GBRAM, for instance, contain achievement and maintenance goals while other methods do not (Ragev & Wegmann, 2005:356). In order to create the framework for this study, each of these components should be examined to identify the most appropriate components to guide the requirements elicitation.

2.2.4.2 GORE METHODS AND RE

Aljahdali *et al.* (2011:331) provides Table 2-9 below, which shows where some of the methods mentioned above are used during the GORE process. The phases that are evident in the GORE process are associated with these techniques/models/methods.

Table 2-9: GORE methods application (Aljahdali *et al.*, 2011:331)

Phase	Activity	Method
Elicitation	Domain analysis	GSTH

	Requirement and assumption identification	GSTH GOIG
Analysis	Classifying	GBRAM A-BT AGORA VVA
	Modelling	GBRAM A-BT AGORA VVA
	Elaboration	GBRAM A-BT AGORA VVA
	Conflict identification and resolution	A-BT AGORA VVA
	Prioritisation	AGORA VVA
Specification		DOSS DTEBS
Requirement Management	Requirement change/ Evolution management	AGORA

	Traceability	AGORA GBRAM A-BT DTEBS DOSS VVA
	Conflict management	AGORA
	Measurement	AGORA

Table 2-9 illustrates the different methods most suited to each of the different phases during the GORE process. The focus of the discussion here will be on the methods selected for requirements elicitation, GSTH and GOIG. These two methods were chosen for different activities. GSTH was selected both for domain analysis and requirement and assumption identification while GOIG was selected only for requirement and assumption identification. GSTH, as previously discussed at Section 2.2.4.1, uses heuristics in order to elicit goals. This was explained by giving the example of an enterprise whose highest goal will be to survive, and then applying heuristics to identify the sub-level goals (Ragev & Wegmann, 2005:356). It is clear to see the motivation of using GSTH with the use of heuristics to elicit goals and why it is selected for the elicitation phase. GSTH is also selected for the domain analysis activity because of the different levels of goals associated with GSTH, and also for the identification of relationships between the different levels of goals (Ragev & Wegmann, 2005:356). GOIG on the other hand looks at different ways by which ideas can be created in order to identify and elicit goals. The process works as follows (Oshiro *et al.*, 2003:363): The needs of the customer are set as the main goals. A goal is selected from the list of goals and ideas are generated which are related to the selected goal. The ideas are grouped together and associations between these goals are identified. The group of ideas is related back to the list of the goals first selected. This method focuses strongly on the needs of the customer, but it is also easy to see that the needs of the organisation and the developers are not seen as especially important. Table 2-9, when looking at the two methods GSTH and GOIG, indicates that there is still room for improvement. This can include adding support for different levels of goals when using GOIG or adding a more flexible means of identifying goals (such as that of GOIG) when using GSTH. Thus, concluding from Table 2-9, methods can still be altered in order to provide a more effective manner of requirements elicitation.

Table 2-10, provided by Horkoff and Yu (2011:678), gives a more detailed view of different methods identified in the literature. This table provides a partial section of the original table by Horkoff and Yu (2011:678) relevant to the scope. . The first column of the table focuses on the approach of the indicated models (indicated by source). The approach is divided into three parts, depending on whether or not the analysis satisfaction approach is forward or backward, and whether or not human intervention is needed (Horkoff & Yu, 2011:677). The Y represents yes, N represents No and M represents maybe.

Table 2-10: Different GORE methods in literature (Horkoff & Yu, 2011:678)

Paper	**Approach**			**Additional Notation Support**		
	Satisf Forwd	Satisf Backwrd	Human Interv	Dependencies	Soft-Goals	Contribution Links
Chung & do Prado Leite (2009:263)	Y	N	Y	N	Y	Y
Giorgini *et al*. (2003:1)	Y	N	N	N	N	Y
Sebastiani *et al*. (2004:20)	Y	Y	N	N	M	Y
Giorgini *et al*. (2005:159)	Y	Y	N	M	Y	Y
Horkoff and Yu (2009:145)	Y	N	Y	Y	Y	Y
Maiden *et al*. (2007:49)	Y	N	Y	Y	Y	Y
Amyot *et al*. (2010:841)	Y	N	N	Y	Y	Y

Asnar and Giogini (2006:55)	Y	Y	N	N	M	Y
Letier and Van Lamsweerde (2004:53)	Y	Y	N	M	N	N
Horkoff and Yu (2010:59)	Y	Y	Y	Y	Y	Y
Wang *et al.* (2007:296)	Y	Y	N	N	M	Y
Franch and Maiden (2003:81)	N	N	N	Y	Y	N
Franch *et al.* (2004:348)	N	N	N	Y	Y	N
Franch (2006:495)	N	N	Y	Y	Y	Y
Horkoff *et al.* (2006:21)	N	N	N	N	N	M
Bryl *et al.* (2006a:533)	N	N	N	Y	N	N
Bryl *et al.* (2009:243)	N	N	Y	Y	N	N
Asnar *et al.* (2007:140)	Y	Y	Y	Y	M	Y
Gans *et al.* (2005a:587)	N	N	Y	Y	N	N
Wang and Lesperance (2001:59)	N	N	N	N	N	N

Gans *et al*. (2005b:68); Gans *et al*. (2005a:587)	N	N	Y	Y	Y	Y
Gans *et al*. (2003:4)	N	N	N	Y	N	N
Fuxman *et al*. (2003:327); Fuxman *et al*. (2001:174)	N	N	M	Y	Y	N
Giorgini *et al*. (2006:257)	N	N	N	Y	N	N
Bryl *et al*. (2006b:33)	N	N	N	Y	N	N

The purpose of satisfaction forward and satisfaction backward is to indicate the type of satisfaction analysis, that is, the analysis of how well the selected model achieved the goals. The backwards satisfaction propagation works as follows. The high-level goals are selected as well as the desired output from each of these goals. The user works backwards to create a path that will lead to high-level goals. This in turn will create other goals (Horkoff & Yu, 2013:305). The forward satisfaction propagation uses input values with the initial goals. The values are used with the goals and the output is then used with the next goals, and so on. This process will continue until a predefined point has been reached. This process will allow the user to look at all the goals with any conflicts that may occur (Horkoff & Yu, 2013:205). Horkoff and Yu (2013:305) describe various methods and how the following table is applied to it. In order to better understand Table 2-10, an example is discussed below (Horkoff & Yu, 2013:205).

- The explanation was given in the context of the NFR framework. This framework makes use of both forward satisfaction and backward satisfaction. The satisfaction of the NFR framework uses labels to indicate whether or not a goal has been satisfied. The label *satisfied* is applied to indicate satisfactory completion of the goal while the label *denied* indicates that the goal was not satisfied. The process begins where a label is created between a sub goal and its parent. This process of parent and sub goal indicates the bi-direction of the satisfaction. The label will indicate the satisfaction as mentioned previously. This method will also help to identify whether or not goals cause conflicts and whether or not there is a need for human intervention. Human intervention is also needed in cases where some goals attract more than one label.

The final three columns on the right of Table 2-10 indicates the additional notations supported by the various models. The first column under this section indicates if there is support for dependencies, that is, indicating if one goal is dependent on another. The second column indicates if the model supports the use of soft-goals (discussed in Chapter 2.1). The last column indicates if the use of contribution links is evident in the model. The contribution links indicate what goals contribute to the satisfaction of other goals (Horkoff & Yu, 2013:202).

Following Table 2-10, Horkoff and Yu (2011:679) provide Table 2-11 below. It indicates the additional information needed for each of the procedures showed previously.

Table 2-11: Procedures for additional information (Horkoff & Yu, 2011:679)

Additional Information	**Procedure requiring the information**
Goal cost	Satisfaction Analysis: Sebastiani *et al*. (2004:20); Asnar and Giogini (2006:55); Giorgini *et al*. (2005:159); Asnar *et al*. (2007:140). Planning: Bryl *et al*. (2006a:533).
Risk	Satisfaction Analysis: Asnar and Giogini (2006:55). Planning: Asnar *et al*. (2007:140).
Textual arguments	Satisfaction Analysis: Maiden *et al*. (2007:49). Metrics Model Checking: Kaiya *et al*. (2002:13).
Probalistic information	Satisfaction Analysis: Giorgini *et al*. (2005:159); Letier and Van Lamsweerde (2004:53).
Events and treatments	Satisfaction Analysis: Asnar and Giogini (2006:55).
Importance/ priority	Satisfaction Analysis: Amyot *et al*. (2010:841). Metrics: Franch *et al*. (2004:348); Amyot *et al*. (2010:841). Simulation: Wang and Lesperance (2001:59).

Actor capabilities	Planning: Bryl *et al*. (2006a:533); Bryl *et al*. (2009:243); Asnar *et al*. (2007:140). Model Checking: Bryl *et al*. (2006b:33).
(Pre/post) conditions/ Temporal information	Simulation: Wang and Lesperance (2001:59); Gans *et al*. (2005a:587); Gans *et al*. (2005b68); Gans *et al*. (2003:4). Model Checking: Fuxman *et al*. (2001:174); Fuxman *et al*. (2003:327).
Delegation/ ownership	Model Checking: Gans *et al*. (2002:328); Bryl *et al*. (2006b:33).
Trust	Planning: Asnar *et al*. (2007:140). Simulation: Gans *et al*. (2003:4). Model Checking: Giorgini *et al*. (2006:257); Bryl *et al*. (2006b:33).
Speech acts	Simulation: Gans *et al*. (2003:4).
Confidence and distrust	Simulation: Gans *et al*. (2003:4).
Preferences	Model Checking: Kaiya *et al*. (2002:13).
Cardinalities	Simulation: Wang and Lesperance (2001:59). Model Checking: Fuxman *et al*. (2003:327).

The information illustrates which sources may be used to obtain the additional information shown. For example, when actor capabilities (row 7) is needed, the methods described by Bryl *et al*. (2006a:533), Bryl *et al*. (2009:243), and Asnar *et al*. (2007:140) can be used for the planning. Model checking can then be used by the method proposed by Bryl *et al*. (2006b:33). It is important to note that this table is heavily based on the analysis of goals but this can also lead to identification of new goals. Through the process of analysis, new goals can be identified and thus this table is important. In order to create a framework with the focus on elicitation, all aspects regarding elicitation should be looked at, including processes that can lead to identification of new goals.

Up until this point, this chapter has discussed what GORE is, the important phases in the RE process related to requirements elicitation, some of the different GORE methods that can be used, and some of the factors that can influence the use of the methods. The final part of the discussion will provide a clearer indication of when to use which GORE method. This is important because it will help to narrow the choice of methods most suitable for requirements elicitation. Table 2-12, provided by Horkoff and Yu (2011:680), maps different GORE techniques to certain objectives. This table includes the category, the question asked, and the recommended procedure.

Table 2-12: Application of different GORE methods (Horkoff & Yu, 2011:680)

Category	Guidelines	Recommended Procedure
Domain Understanding	Does the domain: Contain a high degree of social interaction? Contain many stakeholders with different goals? Involve many interacting systems?	Try: Agent Approaches: i*/GRL Satisfaction Analysis - Amyot *et al*. (2010:841); Horkoff and Yu (2009:145); Horkoff and Yu (2010:59); Maiden *et al*. (2007:49). i* Metrics - Franch (2006:495); Franch and Maiden (2003:81); Franch *et al*. (2004:348). Tropos Metrics, Planning, or Model Checking - Asnar *et al*. (2007:140); Bryl *et al*. (2006a:533); Bryl *et al.* (2009:243); Bryl *et al.* (2006b:33); Fuxman *et al*. (2003:327); Fuxman *et al*. (2001:174); Gans *et al*. (2002:328). SNET - Gans *et al*. (2005b:68); Gans *et al*. (2003:4); Gans *et al*. (2005:587).
	Is the level of detail important at this stage? Is detailed information, such as cost, probabilities, and conditions, available?	Try: Quantitative or Detailed Information: Tropos Probabilistic Satisfaction Analysis - Asnar and Giogini (2006:55);

		Giorgini *et al*. (2003:1); Sebastiani *et al*. (2004:20); Giorgini *et al*. (2005:159). KAOS Satisfaction Analysis - Letier and Van Lamsweerde (2004:53). GRL Quantitative Analysis - Amyot *et al*. (2010:841). i* Quantitative Metrics - Franch (2006:495); Franch and Maiden (2003:81); Franch *et al*. (2004:348). Tropos Planning - Asnar *et al*. (2007:140); Bryl *et al*. (2006a:533); Bryl *et al.* (2009:243); Bryl *et al.* (2006b:33). Tropos Model Checking - Bryl *et al.* (2006b:33); Fuxman *et al*. (2003:327); Fuxman *et al*. (2001:174); Gans *et al*. (2002:328). SNET - Gans *et al*. (2005b:68); Gans *et al*. (2003:4); Gans *et al*. (2005a:587). i* Simulation - Wang and Lesperance (2001:59). Model Checking: Tropos - Bryl *et al.* (2006b:33); Fuxman *et al*. (2003:327); Fuxman *et al*. (2001:174); Gans *et al*. (2002:328).
Communication	Is communication with stakeholders needed? Is validation of the requirements in the model needed? Is	Try: Forward Satisfaction Approaches: NFR - Chung & do Prado Leite (2009:363).

	justification for recommendations needed?	Tropos - Asnar and Giogini (2006:55); Giorgini *et al*. (2003:1); Sebastiani *et al*. (2004:20); Giorgini *et al*. (2005:159). KAOS - Letier and Van Lamsweerde (2004:53). i* - Horkoff and Yu (2009:145); Maiden *et al*. (2007:49). GRL - Amyot *et al*. (2010:841).
Model Improvement	Is there a high level of confidence in the accuracy, structure, and completeness of domain knowledge and models?	If not, try: Interactive Approaches: NFR - Chung & do Prado Leite (2009:363). i* - Horkoff and Yu (2009:145); Horkoff and Yu (2010:59); Maiden *et al*. (2007:49). Tropos - Asnar *et al*. (2007:140); Bryl *et al.* (2009:243). SNET - Gans *et al*. (2005b:68); Gans *et al*. (2005a:587). i* Metrics - Franch (2006:495);
	Is verification of critical properties of the model needed?	Try: Model Checking: Tropos - Bryl *et al.* (2006b:33); Fuxman *et al*. (2003:327); Fuxman *et al*. (2001:174); Gans *et al*. (2002:328). SNET - Gans *et al*. (2005b:68); Gans *et al*. (2005a:578).
Scoping	Is the determination of the system scope important?	Try:

		Agent Approaches: i*/GRL Satisfaction Analysis - Amyot *et al*. (2010:841); Horkoff and Yu (2009:145); Horkoff and Yu (2010:59); Maiden *et al*. (2007:49). i* Metrics - Franch (2006:495); Franch and Maiden (2003:81); Franch *et al*. (2004:348). Tropos Metrics, Planning, or Model Checking - Asnar *et al*. (2007:140); Bryl *et al*. (2006a:533); Bryl *et al.* (2009:243); Bryl *et al.* (2006b:33); Fuxman *et al*. (2003:327); Fuxman *et al*. (2001:174); Gans *et al*. (2002:328). SNET - Gans *et al*. (2005:68); Gans *et al*. (2005:587).
Requirements Elicitation	Is there a need for more high-level requirements? Do you need to prompt for further elicitation?	Try: Interactive Approaches: NFR - Chung & do Prado Leite (2009:363). i* - Horkoff and Yu (2009:145); Horkoff and Yu (2010:59); Maiden *et al*. (2007:49). Tropos - Asnar *et al*. (2007:140); Bryl *et al.* (2009:243). SNET - Gans *et al*. (2005b:68); Gans *et al*. (2005a:587). i* Metrics - Franch (2006:495);
	Is there a need for detailed system requirements?	Try: Quantitative or Detailed Information: Tropos Probabilistic Satisfaction Analysis - Asnar and Giogini (2006:55);

		Giorgini *et al*. (2003:1); Sebastiani *et al*. (2004:20); Giorgini *et al*. (2005:159). KAOS Satisfaction Analysis - Letier and Van Lamsweerde (2004:53). GRL Quantitative Analysis - Amyot *et al*. (2010:841). i* Quantitative Metrics - Franch (2006:495); Franch and Maiden (2003:81); Franch *et al*. (2004:348). Tropos Planning - Asnar *et al*. (2007:140); Bryl *et al*. (2006a:533); Bryl *et al.* (2009:243); Bryl *et al.* (2006b:33). Tropos Model Checking - Bryl *et al.* (2006b:33); Fuxman *et al*. (2003:327); Fuxman *et al*. (2001:174); Gans *et al*. (2002:328). SNET - Gans *et al*. (2005b:68); Gans *et al*. (2003:4); Gans *et al*. (2005a:587). i* Simulation - Wang and Lesperance (2001:59).
	Is there a need to quantify the consideration of non-functional requirements? Is the requirements difficulty to quantify?	Try: Approaches supporting soft-goals or contributions: NFR - Chung & do Prado Leite (2009:363). i* Satisfaction Analysis: Horkoff and Yu (2009:145); Horkoff and Yu (2010:59); Maiden *et al*. (2007:49). Tropos Satisfaction Analysis: Asnar and Giogini (2006:55); Giorgini *et al*.

		(2003:1); Sebastiani *et al*. (2004:20); Giorgini *et al*. (2005:159). Tropos Model Checking - Fuxman *et al*. (2003:327); Fuxman *et al*. (2001:174). GRL - Amyot *et al*. (2010:841). i* Metrics - Franch (2006:495); Franch and Maiden (2003:81); Franch *et al*. (2004:348). SNET - Gans *et al*. (2005b:68); Gans *et al*. (2003:4); Gans *et al*. (2005a:587).
	Is there a need to capture domain assumptions?	Try: Approaches using Satisfaction Arguments: i*Satisfaction Arguments: Maiden *et al*. (2007:49).
Requirements Improvement	Are the following important in the system and under critical consideration? • Safety • Security • Privacy • Risks	Try: Analysis over Specific Constructs or Metric Approaches: KAOS - Letier and Van Lamsweerde (2004:53). i* Metrics - Franch (2006:495); Franch and Maiden (2003:81); Franch *et al*. (2004:348). AGORA - Kaiya *et al*. (2002:12). Tropos Risk, Trust, and Security - Asnar and Giogini (2006:55); Asnar *et al*. (2007:140); Bryl *et al.* (2006b:33); Gans *et al*. (2002:328). SNET Trust - Gans *et al*. (2003:4).

	Is there a need to find errors and inconsistencies in the requirements?	Try: Model Checking: Tropos - Bryl *et al.* (2006b:33); Fuxman *et al*. (2003:327); Fuxman *et al*. (2001:174); Gans *et al*. (2002:328). SNET - Gans *et al*. (2005b:68); Gans *et al*. (2005a:587).
Design	Are there enough high-level design alternatives?	If not, try: Agent, Planning, Forward and Backward Satisfaction Approaches: NFR - Chung & do Prado Leite 2009:363. i* Satisfaction Analysis - Horkoff and Yu (2009:145); Horkoff and Yu (2010:59); Maiden *et al*. (2007:49). Tropos Planning - Asnar *et al*. (2007:140); Bryl *et al*. (2006a:533); Bryl *et al.* (2009:243); Bryl *et al.* (2006b:33). KAOS - Letier and Van Lamsweerde (2004:53). GRL Forwards Satisfaction Analysis - Amyot *et al*. (2010:841). SNET Planning - Gans *et al*. (2005b:68); Gans *et al*. (2005a:587).
	Are there enough detailed design alternatives?	If not, try: Quantitative Planning, Forward and Backward Satisfaction Approaches: KAOS Satisfaction Analysis - Letier and Van Lamsweerde (2004:53). GRL Forward Satisfaction Analysis - Amyot *et al*. (2010:841).

		Tropos Planning - Bryl *et al*. (2006a:533); Bryl *et al.* (2009:243). SNET Planning - Gans *et al*. (2005b:68); Gans *et al*. (2005a:587).
	Is there a need to evaluate and choose between high-level design alternatives?	Try: Satisfaction Analysis, Metrics and Agent Approaches: KAOS Satisfaction Analysis - Letier and Van Lamsweerde (2004:53). i* Forward Satisfaction - Horkoff and Yu (2009:145); Maiden *et al*. (2007:49). GRL Satisfaction Analysis - Amyot *et al*. (2010:841). i* Metrics - Franch (2006:495); Franch and Maiden (2003:81); Franch *et al*. (2004:348). Tropos Risk - Asnar *et al*. (2007:140).
	Is there a need to evaluate and choose between detailed design alternatives?	Try: Quantitative or Detailed Information: Tropos Probabilistic Satisfaction Analysis - Asnar and Giogini (2006:55); Giorgini *et al*. (2003:1); Sebastiani *et al*. (2004:20); Giorgini *et al*. (2005:159). KAOS Satisfaction Analysis - Letier and Van Lamsweerde (2004:53). GRL Quantitative Analysis - Amyot *et al*. (2010:841). i* Quantitative Metrics - Franch (2006:495); Franch and Maiden (2003:81); Franch *et al*. (2004:348).

		Tropos Planning - Asnar *et al*. (2007:140); Bryl *et al*. (2006a:533); Bryl *et al.* (2009:243); Bryl *et al.* (2006b:33). Tropos Model Checking - Bryl *et al.* (2006b:33); Fuxman *et al*. (2003:327); Fuxman *et al*. (2001:174); Gans *et al*. (2002:328). SNET - Gans *et al*. (2005b:68); Gans *et al*. (2003:4); Gans *et al*. (2005a:587). i* Simulation - Wang and Lespérance (2001:59).
	Is there a need for an acceptable process?	Try: Planning Approaches: Tropos Planning - Asnar *et al*. (2007:140); Bryl *et al*. (2006a:533); Bryl *et al.* (2009:243); Bryl *et al.* (2006b:33). SNET Planning - Gans *et al*. (2005b:68); Gans *et al*. (2005a:587).
	Is there a need for testing the runtime operations before they are implemented?	Try: Simulation Approaches: SNET - Gans *et al*. (2005b:68); Gans *et al*. (2003:4); Gans *et al*. (2005a:587). i* Simulation - Wang and Lesperance (2001:59).

Table 2-12 provides a deeper look at the application of different methods in different scenarios. The following questions were evident when referring to the elicitation of goals (as illustrated in the table):

- Is there a need for more high-level requirements?
- Do you need to prompt further elicitation?

- Is there a need for detailed system requirements?
- Is there a need for the consideration of non-functional requirements and is the requirements difficult to quantify?

Studying these questions more closely reveals that, even without the table, some of the methods already discussed can be used. The need for higher-level requirements can be ascertained by using the NFR framework, as already discussed. Thus, this table is very useful in terms of this study. In order to focus on the elicitation process, we can look at the methods mentioned in this table and use them to identify the problems. Together with the requirements elicitation, communication is also evident in the table. Communication between stakeholders and agents is very important during the GORE process and the elicitation phase and thus, the methods opposite of the question in the table, can be studied. Although the study focuses on the elicitation of requirements, it is necessary to look at all these categories to get a clearer picture of the position of the elicitation process within GORE. As mentioned before, requirements elicitation can be carried out throughout the entire development phase and thus these other phases of the GORE process are also important.

2.2.5 CONCLUSION

This part of the literature review focused on GORE. The first part looked at what exactly GORE is and where the goals that are evident in GORE come from. The second part focused on the GORE process itself, discussing the different phases and practices found within GORE. The final part of this chapter looked at the different GORE methods and when they should be applied. The literature revealed that there are many different methods, each with its own focal point and best scenario for application. The tables provided in Section 2.2.4.2 showed that each of these methods can be applied in various scenarios and that more than one method can be used to solve a particular problem.

The literature also showed that some of these methods were developed in order to cater for some shortcoming, for example NFR focused on the non-functional requirements during the RE process. The literature also revealed that little research has been done on the elicitation of requirements in GORE. Some of the methods (as shown in Section 2.2.4.2) cater for various aspects, which can include elicitation, but requirements elicitation is not the focus point. This study will therefore focus on the elicitation of requirements in GORE. Information from the literature and data collected from the industry will be used to develop a framework focused on requirements elicitation as well as communication with the stakeholders.

CHAPTER 3 - RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter will discuss the research method used for the study. The first part of the chapter will describe the different research paradigms. Next, the election of the most suitable paradigm will be discussed. The research paradigms each consist of various research strategies that can be used and this will be discussed. Following the research strategy, the data collection method will be explained as well as the application of the method in the study. The last section will discuss the data analysis used.

Research may be conducted in various ways, but the most common classification of research can be divided into quantitative and qualitative (Myers, 1997:242). Each of these classifications, whether quantitative or qualitative, is based on an underlying assumption (or epistemology). The term epistemology is explained by Hirschheim (1985:13) as the theory of our knowledge with the focus on how we acquire knowledge. Epistemology can be divided into two aspects, what knowledge is, and how is it obtained. Furthermore, the underlying research paradigm, which can be positivistic, critical or interpretive, will influence and guide the research. In the following section we will look briefly at the difference between qualitative and quantitative research and at the epistemological aspects of qualitative research.

3.2 RESEARCH PARADIGMS

3.2.1 QUALITATIVE VS. QUANTITATIVE RESEARCH

The selection of qualitative or quantitative research is determined by certain aspects, which include the assumptions that are made about the world, the purpose, the approach, and the role of researcher (Firestone, 1987:16). Quantitative research is based on the assumption that there are certain facts and that these facts should be seen as the reality instead of the beliefs of the researcher. Qualitative research is based on the researcher's beliefs about the environment under study. The purpose of quantitative research is to identify and explain the cause of change in the environment by using measurement. Qualitative research, on the other hand, attempts to understand the change through participating in the environment (Firestone, 1987:16). The approach in quantitative research is based on experimentation in order to prevent an error such as being bias. Qualitative research, again by participation, helps the researcher to understand the situation. Lastly, the role of the researcher in quantitative research is unbiased, in contrast to qualitative research where the researcher immerses himself/herself in research (Firestone, 1987:16).

This study was conducted using quantitative research. The objective is to identify shortcomings in GORE methods in terms of requirements elicitation. The shortcomings will be addressed through the creation of a new framework. This objective corresponds to the points mentioned in the previous paragraph and hence quantitative research was undertaken. The underlying epistemologies for quantitative research and its three paradigms – positivist, interpretive, and critical – will be discussed next.

3.2.1.1 POSITIVIST RESEARCH PARADIGM

The first research paradigm is described by Oates (2006:283) as the oldest of the three paradigms. This paradigm is used for research in the natural sciences and is called the *"scientific method"*. This paradigm has evolved over the past hundred years and embraces two basic assumptions (Oates, 2006:283). The first states that our world is not random but ordered and regular. The second assumption states that we can investigate our world objectively. The positivist research paradigm thus aims to find these laws, regularities, and patterns (the order and regularity mentioned in the first assumption) by different methods, mainly experiments (as mentioned in connection with the role of the researcher in quantitative research). Furthermore, Johnson and Onwuegbuzie (2004:14), state that the *"observer is separate from the entities that are subject to observation"* and the researcher implementing the enquiry *"should be objective"*.

3.2.1.2 INTERPRETIVE RESEARCH PARADIGM

Oates (2006:292) defines interpretive research as follows:

> *"Interpretive research in IS and computing is concerned with understanding the social context of an information system: the social processes by which it is developed and constructed by people and through which it influences, and is influenced by, its social setting."*

The implementation of interpretive research does not attempt to prove or disprove a certain hypothesis but rather to identify and explain how the various factors in a specific social setting relate to each other and to ascertain the interdependencies of the factors. The use of interpretive methods begins with what we know of reality, which includes human action. We know that it is a social creation of human actors and that our theories regarding reality is what we use to make sense of the environment and world around us (Walshman, 2006:320). There is a certain interaction between the researcher and the individual under study which allows for the uncovering of deeper meaning (Ponterotto, 2005:129).

3.2.1.3 CRITICAL RESEARCH PARADIGM

The last paradigm to mention is the critical research paradigm. Cecez-Kecmanovic (2007:1446) describes critical information systems as research that *“donates a wide range of diverse research endeavours aimed at revealing, criticising, and explaining technological developments and the use of information systems (IS) in organisations and society that, in the name of efficiency, rationalization and progress, increase control, domination, and oppression and produce socially detrimental consequences.”* To simplify the above statement, this research paradigm aims to change a situation. The researcher does not want to accept the status quo and challenges conditions that are dominant. Oates (2006:296) further defines this paradigm as research that is *“concerned with identifying power relations, conflicts and contradictions”* and can be used to enable individuals to eliminate these issues. Critical research also asserts that reality is created and re-created by people, thus creating the component of objectivity (Oates, 2006:824).

3.2.1.4 APPLICATION OF RESEARCH PARADIGM TO THE STUDY

The positivist paradigm was most appropriate for this study because the objective of creating a framework to address the shortcomings of GORE methods in terms of requirements elicitation matched the characteristics of the positivist paradigm best. In order to verify this, the characteristics of the positivist paradigm will be discussed. Oates (2006: 287) lists characteristics of the positivist paradigm, and those related to the study are given below.

- **The world exists independently of humans:** This characteristic implies that there is a world outside our minds, one that is physical as well as social. We can study, capture and measure this independent world. The final framework provided by this study will not be dependent on any individual.
- **Measurement and modelling:** The researcher learns more about the world mentioned above by observation and measurement. Models can also be produced in order to provide a better illustration of how the world works. Furthermore, this characteristic of measurement and modelling implies that there will be a model for each aspect of the world under study (Oates,

2006:286). The use of GORE methods as well as the shortcomings will be identified and measured.

- **Objectivity:** This characteristic implies that the researcher adopts an objective stance in the study. The researcher is an impartial observer and remains neutral at all times. The researcher can identify and collect facts independently of what he/she believes (Oates, 2006:286). The researcher was objective in this research. The data collection methods used ensured that the researcher was not able to influence the participants.

- **Hypothesis testing:** The use of theories and hypothesis is evident in this research method. During the study theories and hypothesis will be either confirmed or refused (Oates, 286). The measurements mentioned in the second point above can be used to confirm or refute in the case of the identification of a hypothesis. In this study, a hypothesis won't be stated and tested.

- **Quantitative data analysis:** This research paradigm uses quantitative data analysis. The use of mathematical models as well as statistical analysis is preferred (Oates, 2006:286). This in turn will ensure that the observations and results can be analysed logically. The data was analysed using quantitative methods. This will be discussed in more detail in Section 3.5.

- **Universal laws:** The final characteristic indicates that this research paradigm focuses on research that looks for generalisations. This means that the researcher looks for patterns or facts that are true regardless of the beliefs of the researcher (Oates, 2006:286). The developed framework can be used when implementing GORE. This a result of the extraction of the universal laws mentioned above using quantitative data analysis as well as an objective research paradigm.

Oates (2006:285) also provides techniques that can be used to conduct research using the positivist paradigm. The following techniques are listed by Oates (2006, 285).

- **Reductionism:** This term means that something complex has been broken down into smaller components, which makes it easier to study complex things. This is illustrated in Figure 3.1, the conceptual model for which the different aspects of GORE and RE were divided into different groups of questions. This allowed the researcher to focus on the different components of GORE and RE and create the framework.
- **Repeatability:** This means that the positivistic research paradigm does not rely on the result of one experiment only but on many. Conclusion and results are not based on just one experiment. This study used questionnaires sent to multiple participants. Various quantitative

data analysis techniques were repeatedly used on the data. Furthermore, this study can also be repeated by other researchers in order to validate the results.

Section 3.2.1.4 discussed how the positivist paradigm was implemented and used in this study. The characteristics of this paradigm fitted well with the requirements of the study. The use of reductionism and repeatability lessened the complexity of GORE while the repeatability component ensured that sufficient data could be collected. The next part of the discussion will focus on the specific research strategy that was used.

3.3 RESEARCH STRATEGY

Oates (2006:35) describes research strategies associated with various research paradigms. The research strategy is described as the "*overall approach to answering your research question*" (Oates, 2006:35). The following Sections will address the various strategies associated with the positivist research paradigm. The final section will discuss which strategy was used in this study and how it was implemented.

3.3.1 SURVEY

A survey is defined by Gable (1994:114) as a collection of methods that use quantitative data analysis. Oates (2006:93) furthermore notes that the idea of a survey is to collect data from a large group of individuals or organisations (Gable, 1994:114) in a standardised and systematic manner. The use of a survey allows the researcher to identify patterns in the data that can be used to create generalisations of a larger population than that of targeted individuals. The form of a survey can vary and can include questionnaires, interviews (telephone, face to face, etc.), data collected from published statistics, etc. (Oates. 2006:93; Gable, 1994:114).

3.3.2 EXPERIMENTS

The use of experiments enables the researcher to test hypotheses in order to identify cause and effect (Oates, 2006:35). Inputs and outputs are measured using quantitative data analysis in order to identify relationships between them. Furthermore, experiments are repeated in order to verify the results and to eliminate other problems such as faulty machines, etc. (Oates, 2006:128). The final characteristic of this research strategy is generalisation, that is, a regular theory, law, or occurring pattern is identified and established. Exception is built into the research, meaning that if a regular theory, law, or accruing pattern does exist it is the work of the researcher to find it (Oates, 2006:229).

3.3.3 DESIGN AND CREATE

The use of the design and create strategy in terms of information technology implies that the researcher aims to develop or create something new, called artefacts (Oates, 2006:302). The researcher using this strategy is objective and employs rational thinking, with mathematical tools and methods which are based on logic rather than human intuition. The artefacts created by the researcher are the representation of reality. This strategy is also seen as a problem solving approach and consists of five steps, which include awareness, suggestion, the development step, and then the evaluation and conclusion (Oates, 2006:112).

3.3.4 RESEARCH STRATEGY APPLIED IN THE STUDY

The method selected for this study was a survey. This method was chosen because a large number of participants was needed for the study. Oates (2006:35) and Gable (1994:114) indicated that this is a suitable method for obtaining data from a large group of individuals and from organisations. Furthermore, by using surveys, different occupations and different levels of employees could be reached. To discuss the use of the survey further, the components mentioned by Oates (2006:94) regarding the planning of the survey will be discussed next.

- **Data requirements:** The first step in planning a survey is to identify what data is needed. This can include data directly or indirectly related to the research subject (Oates, 2006:94). In this study different types of data were needed. In order to identify all the different types, the conceptual model (see Section 3.4.4.3.5 - Figure 3-1) was developed. This model helped to identify what type of data was needed and assisted with the flow of the survey.

- **Data generation method:** The next step in a survey is to identify the method for data generation. This can include the use of questionnaires, documents, interviews, etc. (Oates, 2006:95). This study used a questionnaire as the main method for generating the data. In conjunction with the questionnaires, data gathered from the literature review was also used as supplementary data.

- **Sampling frame:** After the data generation method is identified, the sampling frame needs to be identified. The sampling frame is defined by Oates (2006:95) as *“some kind of list or collection of the whole population of people (ore events or documents) that could be included* *in your survey, from which you will choose a sample".* To simplify, this is the population that will be studied. This study focused on IT developers as well as IT managers as they are the individuals that are most involved with the RE process. They represent a small part of the global IT population and were sufficient for the study.

- **Sampling technique:** After the sampling frame had been identified, a suitable sampling technique was chosen. According to Oates (2006:95), there are two types of these. The first is probability sampling and the other non-probability sampling. This study used a convenience sample which is non-probabilistic, as it was not possible to identify all the IT developers and IT managers in the country to take a random sample of. The respondents were involved in the IT industry. Online IT groups were approached in order to obtain respondents and personal messages were sent to individuals who satisfied the above criteria.

- **Response rate and non-responses:** The response rate is the number of respondents completing the questionnaire divided by the number of requests sent out (Oates, 2006:99). It is important to maximise the response rate. The response rate for this study was about 5%. A covering letter (see Annexure A) was used in the study and stated the purpose of the study and gave other information about the study. In addition to the covering letter, personal e-mails were send to the respondents. This seemed to be the most effective as a general e-mail produced little response.

The next part of the discussion will present a detailed explanation of how the survey was implemented. Using the guidelines provided by Oates (2006:93), the survey was conducted as explained below.

3.3.4.1 IMPLEMENTATION OF THE SURVEY

The survey was conducted from the beginning of June 2015 through to the end of August 2015. The implementation of the survey is discussed below.

3.3.4.1.1 COVERING LETTER

The first part of the survey was to create a cover letter (see Annexure A) to accompany the questionnaire. In order to simplify the process, an electronic covering letter was created and stored on Google Drive. Google Drive is a cloud-based storage facility and offers the service free of charge (although the space is somewhat limited). The covering letter was given a link, and the link was shortened to improve the aesthetics of the message that was sent. Furthermore, shortening the link using another Google service, https://goo.gl, provided additional statistics. This included the ability to track how many times the specific link had been clicked, and indicated the country and the operating system platform that was used during the process.

3.3.4.1.2 IDENTIFYING THE SAMPLE

The next part of the process was to identify the sample for the study. The profile of the individuals to be included in the sample that was used is as follows. The most important aspects were that the individual needed to be involved in the IT sector and have some experience in software development. To identify these individuals, various social media services were used. The first was Facebook. Due to the limitation on time only three groups related to software development was identified. The problem was that each request needed to be confirmed by the group administrator and this was not instantaneous. LinkedIn was also used to search for groups that the researcher could join to post the questionnaire. Other services used included the following forums: My Broadband, Reddit, and an IT-related forum which was used to post the questionnaire. This process seemed not to be the most effective as little response was received, thus other methods were explored.

3.3.4.1.3 CONTACTING THE PARTICIPANTS

The next method was to send personalised messages to personal contacts with in the IT industry. The message asked the recipient to forward the message to colleagues. This method seemed to be more effective and some of the contacts indicated that the personalised message was an effective way to contact other individuals. As the researcher's personal contact list is not very long, LinkedIn was used to invite individuals with the necessary characteristics such as being a developer or IT manager. This took some time as confirmation from the individuals was needed in order to be able to connect with them. This process expanded the contact list to about 1600. A set of people would be invited and their acceptance awaited. LinkedIn provided an option to export the contact list to a .csv file which could be used to extract the e-mail addresses using Microsoft Excel. When the invitees accepted, the list was exported and another set of invitations was sent out. This process was repeated until the necessary number of responses had been received. During this process reminder emails were also sent out. After sending about 900 personalised messages, the researcher followed up with a personal reminder to each individual. This was repeated after 1500 contacts had been reached.

The use of LinkedIn was an effective way of obtaining the necessary respondents. The use of a personalised message was also helpful. Some of the individuals were very friendly and helpful thanks to this, and some indicated that they would forward the message to other. This description indicates the long route it took to get the necessary respondents. In total, about 3000 personalised e-mails were sent and only 156 recipients completed the questionnaire. This provided a response rate of ±5%. The number of clicks, as measured through Google, indicated that the covering letter received 308 clicks while the survey received 411 clicks. Thus only 156 of the 411 invitees that clicked on the link completed the survey.

3.4 DATA COLLECTION

Data collection is defined by Oates (2006:36) as the method used to generate the necessary data. Thus, data collection is *"the means by which you produce empirical (field) data or evidence."* (Oates, 2006:39). As mentioned in Section 3.2.1, this study was based on quantitative research. Moreover, the purpose of the study was to collect quantitative data, that is numeric data (Oates, 2006:39). The following section will discuss the different available methods, as listed by Oates (2006:39), to collect the data.

3.4.1 INTERVIEWS

The first data collection method described by Oates (2006:39) is interviews. An interview can be conducted in various ways, and usually begins with a conversation between the interviewer(s) and interviewee. The researcher is the one in control and can steer the interview in a certain direction. The agenda and the proceedings are determined by the researcher, who also asks most of the questions (Oates, 2006:36). There are different types of interviews, which may include one on one interviews as well as group interviews.

3.4.2 QUESTIONNAIRES

Following interviews, Oates (2006:37) describes questionnaires as another data collection method. They consist of a set of questions that are predefined by the researcher and constructed in a predefined order (Oates 2006:37). The questions are given to respondents to complete and can take various forms. Questions can be in multiple choice form, longer and shorter, open and closed-end, etc. This is determined by the researcher, and the type of data as well as the data analysis method can influence the format of the questions (Oates, 2006:232). Questionnaires usually make use of a pilot or pre-test sent out to a small group of respondents in order to identify any problems or issues with the questionnaire before it is sent out more widely to all the respondents (Oates, 2006:271). Furthermore, questionnaires may be self-administered, without the involvement of the researcher, or they may be researcher-administered whereby the researcher asks the questions (Oates, 2006:221).

3.4.3 OBSERVATION

Another data collection method is observation. This is described by Oates (2006:36) as a method where data is collected through watching people and paying attention to their actions rather than reporting on their actions and what they do. Various senses are involved in this process and it usually requires the researcher to look at the participants, but may also require the researcher to listen, touch, smell, and taste in order to fully complete observation (Oates 2006:36).

3.4.4 DATA COLLECTION USED IN THE STUDY

This study used a questionnaire as the data collection method. The advantages and disadvantages were identified and confirmed the use of this method. Oates (2006:230) lists the following advantages and disadvantages of questionnaires:

3.4.4.1 ADVANTAGES OF USING A QUESTIONNAIRE

- The use of questionnaires is sometimes more economical than other methods of data generation. This advantage contributed greatly to the decision of using questionnaires. Questionnaires could be sent out to a large number of respondents at no cost.
- The questionnaires can include closed-ended questions that can improve the results given by the respondents and provide better control over the different data analyses (Oates, 2006:292)
- The use of questionnaires is not confined to geographical location. This allowed the researcher to send the questionnaire to various respondents across the country.
- The questionnaire was self-administered and consequently the researcher needed no additional skills to conduct the study.

3.4.4.2 DISADVANTAGES OF USING A QUESTIONNAIRE

- The first disadvantage is that the respondents can become frustrated by pre-defined answers and refuse to answer the questions.
- It is difficult to tell if the respondents answered the questions truthfully. If the answers are problematic or unclear, the researcher is not usually able to query the respondent.
- The researcher cannot probe for extra information or clarify vague answers.
- The use of self-administered questionnaires can pose problems if respondents are illiterate or have other handicaps.

In order to overcome the disadvantages certain steps was followed. Questions were made compulsory in order to get the respondents to complete them. In addition, only completed questionnaires were collected. The questionnaire design (see Section 3.4.4.3) helped to state questions as clear as possible to prevent the misunderstanding of the questions. Problems with literacy or handicaps weren't evident during the study.

3.4.4.3 QUESTIONNAIRE DESIGN

The questionnaire was sent in electronic form. The questionnaire was developed using information from the literature review as provided in Chapter 2. The literature provided key components that are evident during the RE process which contributed to the design of the questionnaire. In this section the design of the questionnaire will be discussed in terms of the different categories that will be used in the questionnaire. The sections indicated in the headings are those used in the questionnaire. The information mentioned here is depicted in Figure 3-1 (see Section 3.4.4.3.5) together with the flow of how the questionnaire was designed. The complete questionnaire design is provided in Annexure B.

3.4.4.3.1 DEMOGRAPHIC INFORMATION

The first section of the questionnaire seeks to gather demographic information of the sample. The demographic information was further divided into two parts. One part focused on the individual's demographic information and the other on the demographic information of the company. Table 3-1 illustrates the requested information for each part.

Table 3-1: Demographic information for the individual and the organisation

Demographic Information	
Individual (Section A)	**Organisation (Section B)**
Gender • Choose one item from a list of two.	Size • Choose one item from a list of three
Position • Choose one item from a list of six	Business area/ market • Choose at most two from a list of five
Experience in Systems Development • Choose one item from a list of five.	Type of development • Choose at most three from a list of six
Qualification • Choose one item from a list of seven.	

3.4.4.3.2 PROJECT INFORMATION

The next sections of the questionnaire were related to the last project the participant had worked on. They include questions related to information about the project, the use of systems development methodologies (SDMs), the use of GORE, and the project (process) and system success. Table 3-2 indicates the guideline for creating the questions.

Table 3-2: Project related information

Project Information (Section C)					
The Project	**SDM Usage**	**Traditional RE**	**Use of GORE**	**Success of the Project**	**Success of the System**
Size	Yes/ No	Yes/ No	Yes/ No	Time	High functionality
Nature	SDMs implemented		GORE methods used	Budget	High reliability
Duration				Completed requirements	High maintainability
Type				Fast development	High portability, efficiency and usability

Interaction with other systems				Achieved goals	Satisfied users

- One item should be chosen from a list at each of the questions of the project, indicated in the first column. Type was an open question.
- SDM implementation in the second column is a Likert scale type question. For each of the provided SMDs, the respondent must indicate the level of the extent that the SDM was used. The scale is from 1 (not at all) to 5 (to a greater extent).
- GORE method use in the fourth column is a Likert scale type question. For each of the provided GORE methods, the respondent must indicate the level of the extent that the GORE method was used. The scale is from 1 (not at all) to 5 (to a greater extent).
- The success of the project (column five) and the success of the system (column six) is both Likert scale questions. The respondent must indicate, for each of the statements provided, the level of agreement using a scale from 1 (totally disagree) to 5 (totally agree).

3.4.4.3.3 REQUIREMENTS ENGINEERING INFORMATION

This section focused on the requirements engineering process as a whole and on specific components such as communication and the elicitation techniques (see Table 3-3). The purpose of these questions was to gather information regarding the RE process, regardless of GORE or traditional RE usage.

Table 3-3: Requirements engineering process related information

Requirements Engineering (Section D of the questionnaire)		
RE and the project	**Requirements elicitation**	**Elicitation techniques**
The ease of implementation regarding the RE phases	The elicitation tasks	Extent of implementation per elicitation technique
Changes in requirements	Implementation of elicitation techniques	
	Communication during requirements elicitation	

- Column one and column two is both Likert scale type questions. The respondent must indicate, for each of the statements provided, the level of agreement using a scale from 1 (totally disagree) to 5 (totally agree).
- Elicitation techniques in the third column is a Likert scale type question. For each of the provided elicitation techniques, the respondent must indicate the level of the extent that the technique was used. The scale is from 1 (not at all) to 5 (to a greater extent).

3.4.4.3.4 RE AND GORE IMPLEMENTATION

The final two sections of the questionnaire focus on the implementation of GORE as well as RE. The important information sought in this section is how the usage of GORE is judged by the participants and what negative aspects or problems were identified with use of the GORE method. Table 3-4 indicates the information related to each.

Table 3-4: GORE and traditional RE information

GORE and Traditional RE	
GORE (Section E)	**Traditional RE (Section F)**
Number of methods used	Why not GORE
Strictness and intensity of implementation	Strictness and intensity of implementation
Improvement of RE phases	Specific aspects related to non-GORE usage
Improvement of requirement quality	Sufficient for RE phases
Improvement of communications	Overall sufficiency during development
Overall usage	

- The strictness and intensity of implementation regarding GORE methods (column one) is measured on a scale of 1 to 10.
- The last four rows of column one is all Likert scale type questions. The respondent must indicate, for each of the statements provided, the level of agreement using a scale from 1 (totally disagree) to 5 (totally agree).
- The strictness and intensity of implementation regarding traditional RE (column two) is measured on a scale of 1 to 10.
- The last three rows of column two is all Likert scale type questions. The respondent must indicate, for each of the statements provided, the level of agreement using a scale from 1 (totally disagree) to 5 (totally agree).

3.4.4.3.5 CONCEPTUAL MODEL

Tables 3-1 to Table 3-4 above were used to create the conceptual model indicated by Figure 3-1.

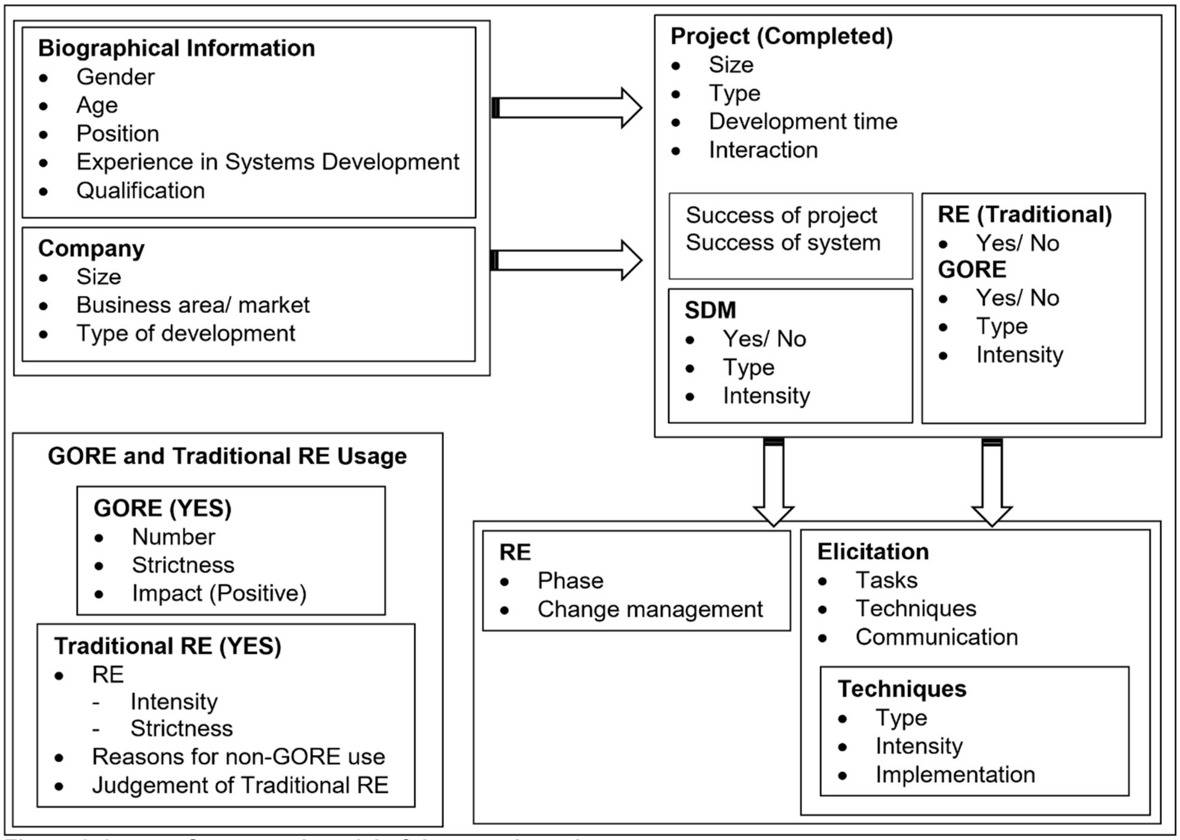

Figure 3-1: Conceptual model of the questionnaire

3.4.4.4 QUESTIONNAIRE IMPLEMENTATION

3.4.4.4.1 CREATING THE QUESTIONNAIRE

The first part of implementing the questionnaire was to construct a version that could be used for pilot testing. The questions, sections and general design were constructed in Microsoft Word and sent out to a small group of individuals, each with the appropriate background to provide correct feedback. They were given five days to complete the survey and provide feedback which could improve the questionnaire. After the pilot study had been conducted, the feedback was processed and the final questionnaire was constructed. The feedback provided was mostly related to formatting issues and incorrect language usage. Feedback related to unclear questions was used to improve the understanding of the relevant questions. For ease of formatting and user friendliness, Google Forms was used to create the questionnaire. Google Forms is a free service that provides excellent tools for the construction of questionnaires. This platform provided multiple choice questions, open questions, and Likert scale questions for use. Furthermore, Google Forms also provided certain error checks to ensure that all the questions are answered and that an incomplete form cannot be submitted. As mentioned above the use of short URL links provided certain statistics but the questionnaire form itself provided extra information. Real-time responses are visible, thus simplifying the process of tracking responses.

The Google Forms platform provided various type of questions to be used. As mentioned different types of questions were used, with the majority being closed-ended. This means that there is a predefined answer from which the participant can choose. There were open-ended questions but they were kept to a minimum. Due to the nature of the questions, quantitative analysis methods will be used to analyse the data. Google Forms provides some data analysis but it was not usable for the study. Help from Statistical Consultation Service at the NWU was used in order to analyse and obtain the necessary results. Google Forms, in general, is a good tool for the creation of questionnaires. As a free tool, there are obvious drawbacks. The most noticeable problem concerned the creation of certain types of questions, for example the participants was asked to indicate yes or no, based on whether or not they use GORE methods. Then, later in the questionnaire they were asked to answer certain questions only if they indicated yes at the question mentioned previously. As a result, the second part couldn’t be made compulsory for all the respondents and was left optional.

3.4.4.4.2 CONCLUSION

The final part of the discussion of the questionnaire discussed the response from the participants. Most of the participants responded to the personal e-mail sent to them, by supplying their input and responses. Although Google Forms does not provide for this, the e-mails were effective. Most of the comments were positive, but some respondents indicated that the questionnaire was a little long. The next section will discuss the data analysis and the methods used.

3.5 DATA ANALYSIS

The final part of the research methodology is the data analysis. Oates (2006:38) describes two types of data analysis, as already mentioned in Section 3.2.1. The first is quantitative data analysis. This type of analysis interprets the collected data by using mathematical approaches. The second type, qualitative analysis, is used in order to identify themes and categories by analysing the words provided by the participants (Oates, 2006:38). The data analysis process helps the researcher to identify themes or relationships. This section will contain brief descriptions of the two types of analysis. The final section will discuss how the selected data analysis method was implemented.

3.5.1 QUALITATIVE DATA ANALYSIS

Qualitative data is defined by Oates (2006:267) as data that is not numeric. This will include "*words, images, sounds, and so on–"* (Oates, 2006:267). The data is normally collected from interview tapes, documents from the company, as well as the models used by the developers. Although quantitative data analysis (see Section 3.5.2) can be used on qualitative data, most "*qualitative data analysis involves abstracting from the research data the verbal, visual or aural themes and patterns that you think are important to you research topics*" (Oates, 2006:267). There are no straightforward and fast rules that can be implemented when using qualitative data analysis. This type of data analysis relies on the skill of the researcher to be able to identify various themes and patterns within the data.

3.5.2 QUANTITATIVE DATA ANALYSIS

Oates (2006:245) defines quantitative data as "…*data, or evidence, based on numbers*". Quantitative data analysis can range from simple methods to more complex methods. A simpler method is to create tables, charts, or graphs in order to represent the data. This will allow the researcher to identify some of the patterns on a higher level. Following this simple analysis method, a more complex method can be implemented, such as simple descriptive statistical techniques. This will allow the researcher to identify more patterns, such as the averages, etc. The statistical analysis can also be done on a more complex level which allows for better pattern and theme recognition (Oates, 2006:246). Oates (2006:246) states that it is important to be familiar with these techniques before data is collected.

3.5.3 DATA ANALYSIS METHODS USED IN THE STUDY

Section 3.5.1 and Section 3.5.2 provide descriptions of the data analysis methods. This section will discuss the method and techniques used in the study. These techniques will be discussed briefly.

Quantitative data analysis was used in this study, mainly because most of the questions asked in the questionnaire produced numerical values. It is important to note that although the questionnaire contained open-ended questions and questions answered in words, quantitative data analysis was still used to some extent. The questions that resulted in answers containing words were converted into numerical values. Open-ended questions were not suitable for quantitative data analysis hence qualitative data analysis was used. The open-ended questions were included to identify various reasons why RE and GORE methods were or were not used. Open-ended questions allowed the participant to provide responses that allowed for answers that could not have been predicted by the researcher.

An important aspect to mention is that the techniques described and used in the study were selected to describe the collected data. Thus, this study is based on descriptive statistics. Descriptive statistics are defined by Mendenhall *et al*. (2013:4) as statistics that "*consist of procedures used to summarize and describe the important characteristics of a set of measurements.*" The set of measurements mentioned here refers to the sample described in Section 3.4.4. The set of measurements thus does not apply to the entire population but only to a sample. In addition to descriptive statistics, Menenhall *et al.* (2013:4), define inferential statistics as "*procedures used to make inferences about population characteristics from information contained in a sample drawn from this population*". The p-values (described below) were reported and due to the use of convenience sampling, effect sizes were used and interpreted.

The next sections (Section 3.5.3.1 to Section 3.5.3.8) discuss the statistical analysis techniques used to analyse the data. The techniques and how they were used in the study will be discussed briefly. The techniques applicable to each of the objectives are as follows.

1. Identify the current state of the GORE method use: Frequencies, two-way contingency tables, and chi-square tests.
2. Identify critical aspects that should be addressed in GORE methods: Frequencies, factor analysis, and correlations
3. Identify key components and the shortcomings of the requirements elicitation process followed in various GORE methods: Frequencies, factor analyses, mean values, effect sizes and t-test.

3.5.3.1 FREQUENCIES

The first technique that was used, was frequencies. The frequency is used to indicate the number of observations (Ott & Longnecker, 2001:65). Although the use of frequencies is a simple method of analysing data, there are different frequency related analyses that can be a bit more complex. These include the creation of frequency histograms, relative frequency histograms, class frequencies, and relative frequencies (Ott & Longnecker, 2001:67). These types of analyses will allow the researcher to visually represent the data using visual aids (Oates, 2006:249) and also extract information regarding intervals, etc.

Frequencies were used in the study to provide a basic indication of the answers the sample yielded. The use of frequencies enabled the researcher to divide the sample into two groups (discussed below). Frequencies were used on all the data in the study.

3.5.3.2 ADVANCED USE OF FREQUENCIES

3.5.3.2.1 TWO-WAY CONTINGENCY TABLES

The correlation between variables was further expanded in the study. In order to complete the research objective, to indicate the current state of GORE method use, the data was split into two groups. The two groups were those participants using GORE and those using traditional RE. Connolly (2007:77) suggests that when dealing with two groups like this, two-way tables (or contingency tables) are the best option for data analysis. The contingency tables indicate, for each of the group, information such as frequencies per variable (for instance an answer to a question), percentages per group per variable, and overall information for both the groups (Connolly, 2007:77).

3.5.3.2.2 CHI-SQUARE

The next technique that was used, was Pearson's chi-square test. The main objective of this test is to indicate whether or not there is a relationship between two variables (or groups like the above) (Field, 2009:687). The formula used to calculate Pearson's chi-square is as follows (Field, 2009:687):

$$x^2 = \sum \frac{(observed_{ij} - model_{ij})^2}{model_{ij}} \quad (1)$$

where i and j represents the rows and columns in the contingency table respectively and $observed_{ij}$ refers to the observed data in the contingency table. The next part is to calculate the $model_{ij}$ which will compute expected frequencies. The expected frequencies are needed because the values of the groups are not equal. The following formula is used for (Field, 2009:689):

$$model_{ij} = E_{ij} = \frac{row\ total_i \times column\ total_j}{n} \quad (2)$$

where n is the number of participants or observations. This value will then be used in formula (1) in order to calculate Pearson's chi square.

3.5.3.3 PHI-COEFFICIENT

The final part is to calculate the Phi-Coefficient. The purpose of the Phi-Coefficient is to describe the effects size of Pearson's chi-square. This is done by dividing the Pearson chi square by the number of samples. Cohen (1988:223) provides the formula:

$$\emptyset = \sqrt{\frac{x^2}{N}} \qquad (3)$$

where N is the number of samples. This will produce a value between 0 and 1 and Cohen (1988:223) describes the effect sizes as follow:

- Small effect = 0.10;
- Medium effect = 0.30; and
- Large effect = 0.50.

During the study these guidelines were used in order to determine if there was a significant difference between the two groups mentioned above.

3.5.3.4 MEANS AND STANDARD DEVIATION

The mean, as defined by Oates (2006:254), is the total of the values that are evident, divided by the number of cases. A more formal definition is provided by Ott and Longnecker (2001:81): "*The arithmetic mean, or mean, of a set of measurements is defined to be the sum of the measurements divided by the total number of measurements*". The term is also sometimes used synonymously to average (Oates, 2006:254; Ott & Longnecker, 2001:81). This study used a sample and not the entire population, hence it is important to differentiate between the mean for the sample and the mean for the entire population. The mean for the sample is denoted by $\overline{X}$ (referred to as X bar) (Taylor & Cihon, 2004:48) while the mean of the entire population is denoted by the Greek symbol μ (Ott & Longnecker, 2001:82). In order to calculate $\overline{X}$, the following formula is used: The equation, provided by Ott and Longnecker (2001:82), is used and modified by replacing $\overline{X}$ with $\overline{y}$:

$$\overline{y} = \frac{\sum_i y_i}{n} \quad (4)$$

where $y_1, y_2, \ldots, y_n$ are the values from the sample with size n. Thus the sum of y_i is divided by n.

The next technique provides the standard deviation. In order to calculate the standard deviation, we first need to calculate the variance as well as the deviation because:

> "*The standard deviation of a set of measurements is defined to be the positive square root of the variance*" (Ott & Longnecker, 2001:92).

First, the deviation indicates the variability of data. The lower the deviation, the closer the measurements are to the centre of the distribution (Ott & Longnecker, 2001:91). Second, the "*variance of a set of n measurements $y_1, y_2, \ldots, y_n$ with mean $\overline{y}$ is the sum of the squared deviations divided by $n - 1$*" (Ott & Longnecker, 2001:91):

$$s2 = s^2 = \frac{\sum_{i=0}^{n}(y-\overline{y})^2}{n-1} \quad (5)$$

The variance is a simpler interpreted function with the aim of indicating the variability within the data. Finally, the standard deviation, denoted by s, is calculated, as mentioned above, by using the square root of the variance (Taylor & Cihon, 2004:49):

$$s = \sqrt{\frac{\sum_{i=0}^{n}(y-\overline{y})^2}{n-1}} \quad (6)$$

Again, both the variance ($s2$) and standard deviation (s) are representative of the sample size. The higher the standard deviation, the higher the distance between each of the measurements from the mean, and vice versa for a lower standard deviation (Oates, 2006:258). The standard deviation together with the means were used on all the measurements obtained from the questions.

3.5.3.5 CRONBACH ALPHA

The Cronbach alpha (or coefficient alpha) is one of the most important statistics when analysing data (Cortina, 1993:98). The Cronbach alpha is used to measure reliability numerically when using scales (Reynaldo & Santos, 1999:1) and although other techniques are available (Cronbach, 1947:13), the Cronbach alpha was used for this study. Cronbach (1947:13) states that there is no best way to measure reliability, and although Cronbach's alpha is by no means perfect, it is the most widely accepted measure of reliability (Cortina, 1993:98). When a scale is used, the items should internally be consistent. All the items should measure the same and must correlate with one another. This high correlation is the indication of reliability (Bland & Altman, 1997:572). Cronbach's alpha, denoted by $\propto$, is different from the standardised item alpha and is calculated using the following formula (Cortina, 1993:99):

$$\propto = \frac{N^2 \times M(COV)}{SUM(\frac{VAR}{COV})} \quad (7)$$

where N^2 is the square of the number of items on the scale, $M(COV)$ represents the mean covariance between items, and $SUM(\frac{VAR}{COV})$ is the sum of all the elements in the variance-covariance matrix. The Cronbach's alpha differs from the standard alpha in two ways. The Cronbach's alpha formula replaces the average covariance with the mean covariance between items and it replaces the sum of the variance-covariance with the variance-covariance matrix. This means that the differences in the item standard deviation is taken into account when calculating Cronbach's alpha (Cortina, 1993:99).

The value of Cronbach's alpha coefficient will range between 0 and 1 with 1 indicating the greatest internal consistency between the items (Bland & Altman, 1997:572). George and Mallery (2003:231) provide the following guidelines for the interpretation of Cronbach's alpha coefficient:

- $\propto \geq 0.9$ – Excellent;
- $\propto \geq 0.8$ – Good;
- $\propto \geq 0.7$ – Acceptable;
- $\propto \geq 0.6$ – Questionable;
- $\propto \geq 0.5$ – Poor; and
- $\propto < 0.5$ – Unacceptable.

Although this is a good rule of thumb, Bland and Altman (1997:572) state that the Cronbach's alpha coefficient is dependent on the number of the items on the scale and thus the acceptable value will vary from study to study. In addition to the number of items on the scale, Peterson (1994:389) indicated that the number of item categories is also influential.

The main application of Cronbach's alpha coefficient in this study was to determine reliability when performing factor analysis. The implementation of factor analysis, discussed next, followed with the calculation of Cronbach's alpha in order to verify the results. Thus, this technique was implemented together with the factor analysis in order to complete the research objectives.

3.5.3.6 FACTOR ANALYSIS

Factor analysis is defined by Foster *et al.* (2006:70) as a "*technique, or more accurately, sets of techniques for identifying the underlying hypothetical constructs to account for relationships between variables*". In addition to this, Cramer (2003:13) describes factor analysis as a collection of techniques that can be used to identify which variables can be grouped together and be used as one variable. The use of factor analysis was complemented by the data as it met the requirements listed by Foster *et al.* (2006:72) which is (1) that the data was measured using scales; (2) the respondents' scores varied on the variables; (3) the variables have correlation. Another important factor is the number of variables to be included. Foster *et al.* (2006:74) suggest that there should be sufficient variables for each factor so that a correlation can be identified. Cramer (2003:15) explains that the minimum size of the sample will vary from one source to another but that the sample should be bigger than the number of variables.

The most widely used and one of the simplest kinds of factor analyses is known as Principle Component Analysis (PCA) (Cramer, 2003:17). The principle component in PCA is also often referred to as factors. Simply put, PCA indicates the percentage of variance of the variables for each of the components (Cramer, 2003:18). It is also important to note that the sum of the PCAs will correspond to the number of variables but not to the number of factors. Thus, each factor will explain a certain percentage of variance of the variables. The next step is to identify which factors to ignore and which to keep. There are two main ways of calculating this (Foster *et al.*, 2006:76), which will be discussed next.

3.5.3.6.1 KAISER CRITERION

The first way is by using the Kaiser criterion – that is, to only use PCAs of which the eigenvalues are greater than 1. The eigenvalue for each of the factors is calculated by the sum of the square of the variables' loadings (Cramer, 2006:18). It is suggested that the use of the Kaiser criterion may result in too many factors thus the use of a *scree* testcan also be used. The *scree* test will identify a break between the factors that explains the largest proportion and the factors that explain a small proportion (Cramer, 2006:19). In addition to this, Kaiser's Measure of Sampling Adequacy (MSA) can also be used. The MSA will indicate if the variables share a common factor. The communality, which is the proportion of variance that is shared by a variable, can also be used. If the communality is closer to 0, it indicates that the variables do not share any of its variance with other variables (Field, 2003:637). Thus, this value will indicate the percentage of variance of the variable that is explained by a given factor.

3.5.3.6.2 ROTATION

The second way is to use rotation. Either orthogonal rotation can be used where the factors are uncorrelated or oblique rotation can be used where the factors are allowed to correlate (Foster *et al.*, 2006:93). The use of orthogonal rotation commonly implements a procedure known as varimax which will maximise the variance between the factors. This results in factors loading high on a small amount of variables and low on the rest (Foster *et al.*, 2003:93). The oblique rotation commonly implements direct *oblimin*, which indicates the contribution of each of the variables to each of the factors and not the contribution between factors (Cramer, 2003:21).

3.5.3.6.3 IMPLEMENTATION

This study used rotation as well as the MSA, together with the eigenvalue. The guidelines for the MSA were used as follows (Kaiser, 1974:35):

- In the 0.90s = marvellous;
- In the 0.80s = meritorious;
- In the 0.70s = middling;
- In the 0.60s = mediocre;
- In the 0.50s = miserable; and
- Below 0.50 = unacceptable.

This was implemented using SAS to indicate which variables' variance is explained by which of the identified factors. Factor analysis was implemented only on suitable data (as described by Foster *et al.* (2006:72)).

3.5.3.7 PEARSON'S CORRELATION COEFFICIENT

The correlation between two variables indicates the strength of the relationship between said variables. This is indicated using Pearson's correlation coefficient. A more formal definition by Ott and Longnecker (2010:107) states that the "*correlation coefficient measures the strength of the linear relationship between two quantitative variables. The correlation coefficient is usually denoted as r.*" In order to determine the correlation coefficient, the following formula can be used (Ott & Longnecker, 2010:107):

$$r = \frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{x_i-\overline{x}}{s_x}\right)\left(\frac{y_i-\overline{y}}{s_y}\right) \quad (8)$$

The two variables, denoted as x and y, are collected from n number of individuals. The means and standard deviation is given for each of the variables where $\overline{x}$ and s_x is for variable x. These properties for variable y is $\overline{y}$ and s_y. This formula standardises the variables y and x in order to make them unit-free. The correlation can vary from -1.00 to +1.00 where +1.00 indicates a perfect relationship and -1.00 indicates no correlation at all (Cramer, 2003:16). The guidelines that used were provided by Cohen (1988:79):

- $r \geq$ .10 = Small effect size;
- $r \geq$ .30 = Medium effect size; and
- $r \geq$ .50 = Large effect size.

In addition to the use of Pearson's correlation coefficient, Spearman's correlation coefficient can also be used denoted by r_s. The Spearman's correlation coefficient is calculated in the same manner as Pearson's correlation coefficient, but the data is ranked before r_s is calculated (Field, 2009:180).

In order to test for statistical significance, the r value is used to calculate a t value (Field, 2009:172):

$$t = r\sqrt{\frac{n-2}{1-r^2}} \qquad (9)$$

where n is the number of samples. The t value is then used to determine a specific $critical\ t$ value which is obtained by using a $t - distribution$ table (Field, 2009:803). This $critical\ t$ together with other variables are used in order to calculate a p value.

The p value indicates a certain probability. The criterion in this study was 95% confidence, which means that only p values below 0.05 were accepted and only these low p values would indicate statistical significance. The use of the p value allows the researcher to accept or dismiss certain statements through probability. If the p value is less than 0.05 it would indicate that there is an effect (based on the t values) between the means with statistical significance (Cohen, 1988:2). This method was used on the applicable data in order to complete the research objectives of the study.

3.5.3.8 EFFECT SIZES AND T-TESTS

Techniques such as the Spearman's correlation coefficient can produce results which indicate statistical significance, but Pallant (2007:207) states that these results do not indicate the degree of association between the two variables. Pallant (2007:207) suggests that the importance of the findings can be assessed through the calculation of the effect size (also referred to as the strength of association). In addition to this description, Tabachhnick and Fidell (2007:54) state that "*Although significance testing, comparison, and parameter estimation help illuminate the nature of group differences, they do not asses the degree to which the IV(s) and DV are related*". The terms IV and DV refer to independent and dependant variables. The effect size will thus indicate the level of association as mentioned above.

There are a number of different statistics for the effect size, one of them being the Cohens' d (Pallant, 2007:208). Cohens' d calculates the difference between the standard deviations of the groups. The strength of the effect size is as follows (Cohen, 1988:17):

- Small effect size: $d \geq 0.2$;
- Medium effect size: $d \geq 0.5$; and
- Large effect size: $d \geq 0.8$.

The effect sizes in this study were calculated using the difference of the means of the two groups mentioned earlier. In order to calculate the effect size, the technique known as a t-test was used.

To begin with, the type of t-test has to be selected. The first is an independent-means t-test which is performed when "*there are two experimental conditions and different participants were assigned to each condition*" (Field, 2009:325). The second is known as the dependent-means t-test and this is performed when "*there are two experimental conditions and the same participants took part in both conditions of the experiment*" (Field, 2009:325). The independent-means t-test was used in this study and divides the difference between the means of two groups by the standard error (SE) of these differences (Field, 2009:334). The pooled variance estimate t-test was implemented. This allowed the two groups to have different sizes as the t-test took into account this difference by weighting the variance of each sample (Field, 2009:336). First, the standard error (SE) of the sampling distribution for each group is determined (Field, 2009:335):

$$Group\ 1: SE\ of\ sampling\ distribution = \frac{s_1}{\sqrt{N_1}} \quad (10)$$

$$Group\ 2: SE\ of\ sampling\ distribution = \frac{s_2}{\sqrt{N_2}} \quad (11)$$

where N_1 and N_2 are the sample size of each group and s_1 and s_2 are the standard deviation of each sample. Following this, the variance of the sampling distribution for each group is calculated (Field, 2009:335):

$$Group\ 1: Variance\ of\ sampling\ distribution = \left(\frac{s_1}{\sqrt{N_1}}\right)^2 = \frac{s_1^2}{N_1} \quad (12)$$

$$Group\ 2: Variance\ of\ sampling\ distribution = \left(\frac{s_2}{\sqrt{N_2}}\right)^2 = \frac{s_2^2}{N_2} \quad (13)$$

The final step of calculating the SE is to take the square root of the variances calculated in the previous step (Field, 2009:336):

$$SE\ of\ the\ sampling\ distribution\ of\ differences = \sqrt{\left(\frac{s_1^2}{N_1} + \frac{s_2^2}{N_1}\right)} \quad (14)$$

Next, the *t*-test equation is completed by using the above equation as follows (Field, 2009:336):

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\left(\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}\right)}} \quad (15)$$

where $\overline{X_1}$ and $\overline{X_2}$ are the means of each of the samples. This is a different formula than the one mentioned in Section 3.5.3. but is also used to determine a specific $critical\ t$ value, which is obtained by using a $t - distribution$ table (Field, 2009:803). This $critical\ t$ together with other variables is used in order to calculate a p value. The criterion again is 95% confidence, which means that only p values below 0.05 were accepted and only these low p values would indicate statistical significance (Cohen, 1988:2).

3.5.4 CONCLUSION

The above techniques (Section 3.5.3.1 through Section 3.5.3.7) were the main statistical methods used for analysing the data. The descriptions of quantitative and qualitative data analysis at the beginning of Section 3.5 identified the type of data needed, thus leading to the use of these techniques. The techniques were implemented with computer software which simplified the process but also improved the quality of the analysis produced. Chapter 4 will present the findings of the analysis.

CHAPTER 4 – RESULTS OF DATA ANALYSIS

4.1 Introduction

This chapter will report the results of the analysed data obtained in the completed questionnaires, as discussed in Chapter 3. In order to improve the interpretation of the analysed data, the results will be presented in a chronological structure. The use of the conceptual model, as presented in Chapter 3, will help to achieve this structure. The results, therefore, will be presented using the following sections:

- Demographic information of the sample;
- Information about the project (as described in Chapter 3);
- The RE process and requirements elicitation; and
- The implementation of GORE and RE.

The presentation of the results according to the points mentioned not only improves the structure of the chapter but also connects the results with the research objectives described in Chapter 1. The first two points contains the results of the questions related to the current state of GORE method use as well as the critical aspects of GORE methods that should be addressed (Objective 1 and 2). The third point contains the results of the questions related to requirements elicitation (Objective 3). The fourth point contains results relating to both the previous three objectives. The purpose of the chapter, as a result of the previous statement, is not only to present the results of the analysed data but also to indicate the information relevant to the research objectives. The objectives listed below will thus be relevant in the presentation of this chapter.

- Identify the current state of GORE method use;
- Identify the critical aspects of GORE methods that should be addressed; and
- Identify the key components and shortcomings of the requirements elicitation process followed in various GORE methods.

The last two objectives are addressed in Chapter 5 and Chapter 6 as they are not completed in this chapter. The next sections of this chapter will provide the results as discussed.

4.2 RESULTS

4.2.1 DEMOGRAPHIC INFORMATION

The demographic information of the participants provided in this section is mainly obtained by using frequencies (F) and percentages. The first part of the section will indicate the overall results in terms of demographic information. The second part will indicate how two groups were identified on the basis of GORE method use and traditional RE.

4.2.1.1 THE INDIVIDUALS

Table 4-1 indicates the frequencies (F) and percentages of the gender of the participants. The sample thus consisted 85.26% of males.

Table 4-1: Descriptive statistics of: Gender

Gender	F	Percentage
Male	133	85.26%
Female	23	14.47%

Table 4-2 indicates the frequencies (F) and percentages of the age of the participants. There were only 2 participants under the age of 22, which indicates that 98.72% of the participants were above 22 years old. In addition, 58.97% of the participants were between 22 and 30 years of age.

Table 4-2: Descriptive statistics of: Age

Age	F	Percentage
18 or less	0	0.00%
19 – 21	2	1.28%
22 – 30	92	58.97%
31 – 40	41	26.28%
41 – 50	14	8.97%
51 – 60	7	4.49%

Table 4-3 indicates the frequencies (F) and percentages of the current occupation of the participants. This revealed that 72.44% of the participants were developers. This is a positive result because it indicated that the questionnaires had reached the intended participants. Only 15.38% of the participants indicated that they occupy a different occupation from those listed.

Table 4-3: Descriptive statistics of: Current position

Current Position	F	Percentage
Chief Information Officer	1	0.64%
Information Systems Manager	5	3.21%
Project manager	6	3.85%
Developer	113	72.44%
System analyst	7	4.49%
Other	24	15.38%

Table 4-4 indicates the frequencies (F) and percentages of the years of experience of the participants. There were 10 participants with experience of less than 1 year. The last three rows indicate the highest frequencies and percentages at 30.13% of participants having between 2 and 5 years of experience. This also indicates that the participants had a high level of work experience.

Table 4-4: Descriptive statistics of: Years of experience

Years of experience	F	Percentage
Less than 1 year	10	6.41%
1 year or more – less than 2 years	23	14.74%
2 years or more – less than 5 years	47	30.13%
5 years or more – less than 10 years	35	22.44%
10 years or more	41	26.28%

Table 4-5 indicates the frequencies (F) and percentages of the participants' highest qualification. A university degree or equivalent, produced the highest percentage of 41.03%. Certificates or diplomas and honours degrees were selected the second most at 21.79% and 23.72%, respectively. This also indicates that the respondents are well trained.

Table 4-5: Descriptive statistics of: Qualification

Qualification	F	Percentage

Senior certificate (High School)	4	2.56%
Certificate or diploma	34	21.79%
University degree or equivalent degree	64	41.03%
Honours degree	37	23.72%
Master's degree	12	7.69%
Doctoral degree	2	1.28%
Other	3	1.92%

4.2.1.2 THE COMPANIES

Table 4-6 indicates (using frequencies (F) and percentages) that 49.36% of the participants were employed in large companies while 32.05% in small companies.

Table 4-6: Descriptive statistics of: Size of company

Qualification	F	Percentage
Small	50	32.05%
Medium	29	18.95%
Large	77	49.36%

Table 4-7 indicates the frequencies (F) and percentages of the companies that operate in a specific market. The participants could have selected at most two. The percentages reported indicate how many companies operate within the specific market. The financial market was the most popular at 74.44% while only 5.13% of the companies were operating in media markets.

Table 4-7: Descriptive statistics of: Market of operation

Market	F	Yes	No	Percentage (Yes)
Retail markets	156	35	121	22.44%
Media markets	156	8	148	5.13%
Internet markets	156	43	113	27.56%
Finance markets	155	74	82	47.44%
Other	155	48	107	30.97

Table 4-8 indicates the frequencies (F) and percentages of the companies that do the specific type of development. The participants could have selected at most two. Systems development was selected the most at 75.64% of the organisations undertaking this type of development. Application development and web development followed, with 61.54% and 66.67% respectively.

Table 4-8 Descriptive statistics of: Type of development

Development Type	F	Yes	No	Percentage (Yes)
Application development	156	90	66	61.54%
Systems development	156	118	38	75.64%
Web development	156	104	52	66.67%
Embedded development	156	26	130	16.67%
Test automation	156	25	131	16.03%
Other	156	15	141	9.62%

4.2.2 THE PROJECT INFORMATION

This section will provide the results of the last project the participants had completed. The first results to be reported are the description of the projects. The subsequent sections will report on the use of SDMs, traditional RE, and GORE during the last project. The results from this analysis also identified a problem regarding the identification of participants who used GORE methods and those who used traditional RE. The solution for this problem will also be discussed.

4.2.2.1 DESCRIPTION OF THE PROJECT

The first description of the project is indicated in Table 4-9. The size of the project was measured, yielding most projects as medium and large at 47.44% and 42.95%, respectively.

Table 4-9: Descriptive statistics of: Size of the project

Size of Project	F	Percentage
Small	15	9.62%
Medium	74	47.44%
Large	67	42.95%

Table 4-10 indicates the frequencies (F) and percentages of the nature of the project. More than half the participants indicated that the projects were new developments while the redevelopment of previous projects was selected least frequently at only 14.10%.

Table 4-10: Descriptive statistics of: Nature of the project

Nature of Project	F	Percentage
New development	86	55.13%
Upgrading a previous project	48	30.77%
Redeveloping a previous project	22	14.10%

Table 4-11 indicates the frequencies (F) and percentages of the duration of the project. A duration of less than 6 months was chosen for 49 of the projects. Projects with a duration of more than 6 months but less than 1 year were the second most popular, with 39 projects.

Table 4-11: Descriptive statistics of: Duration of project

Duration of project	F	Percentage
Less than 6 months	49	31.41%
6 months or more – less than 1 year	39	25.00%
1 year or more – less than 2 years	23	14.74%
3 years or more – less than 4 years	28	17.95%
4 years or more – less than 5 years	7	4.49%
5 years or more	10	6.41%

Table 4-12 indicates the frequencies (F) and percentages of the interaction with other systems of the projects. Only 5.13% had no interaction with other systems. The interaction between 1-2 systems was the most selected.

Table 4-12: Descriptive statistics of: Interaction with other systems

Interaction with other systems	F	Percentage
None	8	5.13%
1-2 systems	56	35.90%

3-4 systems	44	28.21%
More than 5 systems	48	30.77%

4.2.2.2 DISTINCTION BETWEEN GORE AND TRADITIONAL RE

The questionnaire was developed with certain questions which helped to identify which participants used GORE methods and which did not. The results of the answers to whether or not the GORE methods was used (Question C.7) and whether or not traditional RE was used (Question C.8), were the main questions supporting this. Analysis of the questionnaires produced the results in Table 4-13.

Table 4-13: Frequencies for the selection of GORE and traditional RE

Question	Yes	No
Use of traditional RE (Question C.7)	49	107
Use GORE methods (Question C.8)	27	129

Table 4-13 indicated that for traditional RE used during development, 49 of the participants indicated “Yes” while 107 indicated “No”. For GORE methods used during development, 27 participants indicated “Yes” and 129 indicated “No”.

The question following that whether or not GORE methods had been used, contained a list of GORE methods which the participants could use to indicate the extent of implementation of the specific method during development. These questions were limited to only the participants who selected “Yes” as an indication of GORE method use. However, due to limitations in the software that was used, those who indicated “No” could still answer the questions. Thus, in order to identify only GORE users, any participant who indicated an implementation of a GORE method was categorised in this group. The grouping was now not only categorised according the questions in Table 4-13 but also according to the implementation of GORE methods. This method produced the results indicated in Table 4-14. The final frequency of GORE users, which was 42, was almost double that of the original analysis.

Table 4-14: Frequencies of participants per group

Question	N
Use of traditional RE	114
Use GORE methods	42

Two groups were used throughout the data analysis. The next sections of the data analysis will thus refer to the following groups:

- Group 1: Participants using GORE methods;
- Group 2: Participants using traditional RE.

4.2.2.3 GORE AND TRADITIONAL RE

The demographic information reported in Section 4.2.1 and the description of the project provided in Section 4.2.2.1 were both based on the combined responses. This section, however, will report on the demographic information and project information based on Group 1 and Group 2. In addition to the frequencies (F), two-way contingency tables were used to calculate the chi-square value and the Phi-Coefficient. These calculations were used to determine if there was any statistical difference between the two groups regarding the demographic and project information. Table 4-15 reports on the combined results both of Group 1 and Group 2 for all the individual demographic information.

Table 4-15: Frequencies and percentages of individual demographic information for Group 1 and Group 2

Information	Selection	Group 1		Group 2	
		F	Percentage	F	Percentage
Gender	Male	37	88.10%	96	84.21%
	Female	5	11.90%	18	15.79%
Age	18 or less	0	0.00%	0	0.00%
	19 – 21	1	2.38%	1	0.88%
	22 – 30	27	64.29%	65	57.02%
	31 – 40	9	21.43%	32	28.07%
	41 – 50	5	11.90%	9	7.89%
	51 – 60	0	0.00%	7	6.14%
Current position	Chief Information Officer	0	0.00%	1	0.88%

	Information Systems Manager	1	2.38%	4	3.51%
	Project manager	1	2.38%	5	4.39%
	Developer	31	73.81%	82	71.93%
	System analyst	1	2.38%	6	5.26%
	Other	8	19.02%	16	14.04%
Years of experience	Less than 1 year	5	11.90%	5	4.39%
	1 year or more – less than 2 years	7	16.67%	16	14.04%
	2 years or more – less than 5 years	9	21.43%	38	33.33%
	5 years or more – less than 10 years	13	30.95%	22	19.30%
	10 years or more	8	19.5%	33	28.95%
Personal Qualification	Senior Certificate (High School)	3	7.14%	1	0.88%
	Certificate or Diploma	8	19.05%	26	22.81%
	University degree or equivalent degree	18	42.86%	46	40.35%
	Honours degree	10	23.81%	27	23.68%
	Master's degree	2	4.76%	10	8.77%
	Doctoral degree	1	2.38%	1	0.88%
	Other	0	0.00%	3	2.63%

Table 4-16 indicates the frequencies (F) and percentages for each of the groups in terms of the different components of the company information.

Table 4-16: Frequencies and percentages of the different components of the companies for Group 1 and Group 2

Information	Selection	Group 1		Group 2	
		F	Percentage	F	Percentage
Size of the company	Small	16	38.10%	34	29.82%
	Medium	8	19.05%	21	18.42%
	Large	18	42.56%	59	51.75%

Market	Retail market	6	14.29%	29	25.44%
	Media markets	63	7.14%	5	4.39%
	Internet markets	13	30.95%	30	26.32%
	Financial markets	15	35.71%	59	51.75%
	Other	16	38.10%	32	28.32%
Type of development	Application development	25	59.52%	71	62.28%
	Systems development	36	85.71%	82	71.93%
	Web development	27	64.29%	77	67.54%
	Embedded systems development	7	16.67%	19	16.67%
	Test automation	6	14.29%	19	16.67%
	Other	4	9.52%	11	9.65%

Table 4-17 indicates no significant Phi-Coefficient values. In order for the value to be significant, a value of more than 0.5 is needed. The significance, in terms of this table, is an indication of the difference between the two groups. Thus, according to the given values for each of the properties, the personal demographic information of the participants in the sample was not significantly different for each of the groups.

Table 4-17: Chi-square and Phi-Coefficient for individual demographic information

Property	**Chi-Square**	**Phi-Coefficient**
Gender	0.3685	0.0486
Age	4.4603	0.1691
Current position	1.8955	0.1102
Years of experience	7.9272	0.2163
Personal qualification	7.2337	0.2153

Table 4-18 indicates no significant Phi-Coefficient values. In order for the value to be significant a value of more than 0.5 is needed.

Table 4-18: **Chi-square and Phi-Coefficient for the demographic information of the companies**

Property		**Chi-square**	**Phi-Coefficient**
Size	Size of company	1.1538	0.0860
Market	Retail market	2.1938	0.1186
	Media markets	0.4795	-0.0554
	Internet markets	0.3305	-0.460
	Financial markets	3.1670	0.1425
Type of Development	Application development	0.0986	0.0251
	Systems development	3.1651	-0.1424
	Web development	0.1466	0.0307
	Embedded systems development	-	-
	Test automation	0.1293	0.288

Table 4-19 reports the combined results both of Group 1 and Group 2 for the project information. The percentages indicate that there are not many differences between Group 1 and Group 2 regarding the project information. However, all the projects in Group 1 had interacted with at least one other system while 8 of the projects in Group 2 did not have any interaction with other systems.

Table 4-19: **Frequency and percentage of project information for Group 1 and Group 2**

Property	**Selection**	**Group 1**		**Group 2**	
		F	**Percentage**	**F**	**Percentage**
Size of Project	Small	2	4.76	13	11.40
	Medium	21	50.00	53	46.49
	Large	19	45.24	48	42.11
Nature of Project	New development	20	47.62	66	57.89
	Upgrading a previous project	16	38.10	32	28.07
	Redeveloping a previous project	6	14.29	16	14.04
Duration	Less than 6 months	14	33.33	35	30.70
	6 months or more – less than 1 year	9	21.43	30	26.32
	1 year or more – less than 2 years	6	14.29	17	14.91

	3 years or more – less than 4 years	8	19.05	20	17.54
	4 years or more – less than 5 years	1	2.38	6	5.26
	5 years or more	4	9.52	6	5.26
Interaction with other systems	None	0	0.00	8	7.02
	1-2 systems	8	42.86	38	33.33
	3-4 systems	12	28.57	32	28.07
	More than 5 systems	12	28.57	36	31.58

4.2.2.4 USE OF SDMS

This section will report on the use of SDMs during the development of the project. Table 4-20 provide the frequencies (F) and percentages for the usage of a SDM. A scale (1 being "not at all" to 5 being "to a greater extent") was used to indicate to what extent the method had been implemented. The neutral column was omitted in Table 4-20 so that only the applicable results would be reported. 77.56% of the participants indicated that they used SDM's while 22.44% indicate that they didn't use SDM's.

Table 4-20: Frequencies and percentages for SDM and non-SDM usage

Question	F	Percentage
Use of a SDM	121	77.56%
Do not use a SDM	35	22.44%

Table 4-21 indicates the extent of implementation for each SDM. A scale (1 being "not at all" to 5 being "to a greater extent") was used to indicate to what extent the SDM was implemented. Table 4-21 provides the results, for which the frequencies (F) as well as the extent of implementation (in percentage) are reported. The neutral column was omitted in Table 4-21 so that only the applicable results would be reported. Mean values greater than 3 (indicated in dark green) indicates that the SDM was implemented to some extent while mean values below 3 (indicated in light green) indicates that the SDM was implemented to a lesser extent. The dark orange colour in Table 4-21 is used to indicate when a higher percentage of the participants implemented the SDM to some extent while the light orange colour is used to indicate when a higher percentage of the participants implemented the SDM to a lesser extent or not at all. The respondents indicated that SDLC (64.75%), OOAD (59.13%) and RAD (45.59%) was all implemented to some extent. IE (36.84%), XP (34.56%) and UML (29.63%) was indicated to have been the least implemented.

Table 4-21: Frequency, percentage and means of the extent of implementation of SDM's

Method	F.	Mean	Not at all	To a little extent	To some extent	To a greater extent
SDLC	139	3.65	13.67%	7.63%	28.78%	35.97%
OOAD	137	3.49	14.60%	10.22%	29.93%	29.20%
IE	133	2.90	19.55%	17.29%	19.55%	13.53%
XP	136	2.65	34.56%	15.44%	22.79%	13.24%
RAD	136	3.08	19.85%	16.91%	26.47%	19.12%
UML	135	2.75	29.63%	17.78%	22.22%	14.81%

4.2.2.5 USE OF GORE METHODS

This section will report on the use of GORE methods in the projects. Table 4-14 indicated that 42 of the participants used GORE methods. The methods used by these participants were analysed in order to identify the extent of implementation for each method. Table 4-22 indicates the mean, frequencies (F) as well as the extent of implementation (in percentage) of the GORE methods. A scale (1 being "not at all" to 5 being "to a greater extent") was used to indicate the extent to which the method was implemented. The neutral column was omitted in Table 4-22 so that only the applicable results would be reported. Mean values greater than 3 (indicated in dark green) indicates that the GORE method was implemented to some extent while mean values below 3 (indicated with light green) indicates that the GORE method was implemented to a lesser extent. The dark orange colour in Table 4-22 is used to indicate a higher percentage of participants who implemented the GORE method to some extent while the light orange colour is used to indicate when a higher percentage of the participants who implemented the GORE method to a lesser extent or not at all. GBRAM (55.00%), AGORA (35.90%), GOIG (37.50%), DOSS (41.02%), and NFR (50.00%) were implemented to some extent and more while DTEBS (39.48%), VVA (47.37%), i* (55.56%), KAOS (39.47%) and TROPOS (52.63%) were implemented to a lesser extent, or not at all. GBRAM was implemented the most with 55.00% while i* was implemented the least with 50.00% of the participants indicating that they didn't use it at all.

Table 4-22: Frequency, percentage and means of the extent of implementation of GORE methods

Method	F.	Mean	Not at all	To a little extent	To some extent	To a greater extent
GBRAM	40	3.30	20.00	2.50%	27.50%	27.50%
AGORA	39	3.03	23.08	5.13%	17.95%	17.95%
DTEBS	38	2.63	26.32	13.16%	18.42%	5.26%
VVA	38	2.45	36.84	10.53%	7.89%	10.53%
GOIG	40	3.05	22.50	10.00%	15.00%	22.50%
DOSS	39	3.13	17.95	7.69%	25.64%	15.38%
NFR	40	3.38	7.50	10.00%	37.50%	12.50%
i Star	36	2.03	50.00	5.56%	2.78%	2.78%
KAOS	38	2.58	31.58	7.89%	23.68%	2.63%
TROPOS	38	2.26	47.37	5.26%	10.53%	7.89%

Table 4-23 indicates the frequencies and percentages of the number of GORE methods that were implemented during the project.

Table 4-23: Frequencies and percentages of the number of implemented GORE methods

Number of GORE methods implemented	Frequency	Percentage
0	7	24.14%
1	5	17.24%
2	5	17.24%
3	5	17.24%
4	3	10.34%
5	2	6.90%
6	2	6.90%

4.2.2.6 SUCCESS OF THE PROJECT (PROCESS) AND THE SYSTEM (PRODUCT)

The success of the project, also referred to as the success of the process, and the success of the system, also referred to as the product, were the last questions for project information. Questions in the section titled – *Project success*, were relevant to the success of the project while the questions under the title – *Success of the system*, were relevant to the success of the system (See Annexure B).

The participants were asked to identify to what level they agree with the given statement. A scale (1 being “totally disagree” to 5 being “totally agree”) was used to indicate to what level the participants agreed with the statement. The first part of the analysis resulted in an exploratory factor analysis on both sets of statements in order to identify whether or not these statements did in fact relate to the project success and the system success. The factor analysis was done using the level of agreement of statements related to the success of the system and statements to the success of the project. The variables related to each of the statements is provided in Table 4-24.

Table 4-24: Values of the variables related to questions (Project and system success)

Success	Variable	Question
Project	C9_1	The project was completed on time
	C9_2	The project was completed within the budget
	C9_3	The project satisfied all the requirements
	C9_4	The development speed was fast
	C9_5	The project achieved its goals
	C9_6	Overall the project was a success
System	C10_1	The functionality of the developed system is high
	C10_2	The reliability of the developed system is high
	C10_3	The maintainability of the developed system is high
	C10_4	The portability of the developed system is high
	C10_5	The efficiency of the developed system is high
	C10_6	The usability of the developed system is high
	C10_7	The developed system meets user needs
	C10_8	The documentation of the developed system is good
	C10_9	Overall the quality of the developed system is high
	C10_10	Overall the users are satisfied with the developed system
	C10_11	Overall the developed system is a success

Table 4-25 indicates the means, frequencies(F) and percentages of the responses to the success of the system and the success of the project. The neutral column was omitted in Table 4-25 so that only the applicable results would be reported. Mean values above 3 indicate that the participants mostly agreed with the statement (indicated in light green) while mean values greater than 4 indicate that the participants totally agreed (indicated in dark green). The dark orange colour in Table 4-25 is used to indicate whether a higher percentage of participants agreed with the statement.

Table 4-25: **The means, frequencies and percentages of the success of the system and the success of the project**

Method	Mean	F	Totally Disagree	Mostly Disagree	Mostly Agree	Totally Agree
C9_1	3.54	156	5.77%	16.03%	44.23%	18.59%
C9_2	3.56	156	8.97%	7.69%	33.97%	23.72%
C9_3	3.94	156	0.64%	7.69%	48.08%	27.56%
C9_4	3.58	156	5.13%	11.54%	37.82%	21.15%
C9_5	4.13	156	1.28%	1.95%	53.21%	32.05%
C9_6	4.12	156	1.28%	3.85%	46.79%	35.90%
C10_1	4.23	156	0.64%	1.92%	46.79%	39.74%
C10_2	4.06	156	1.28%	5.77%	51.28%	31.41%
C10_3	3.89	156	3.21%	5.13%	41.67%	29.49%
C10_4	3.48	156	8.33%	7.05%	35.90%	17.95%
C10_5	3.89	156	1.92%	6.41%	51.92%	23.72%
C10_6	4.13	156	1.92%	1.92%	53.21%	32.69%
C10_7	4.23	156	0.64%	2.56%	46.15%	40.38%
C10_8	3.21	156	7.69%	21.15%	29.49%	14.10%
C10_9	3.99	156	1.28%	3.85%	52.56%	26.28%
C10_10	3.98	156	1.28%	2.56%	49.36%	26.92%

The variables listed in Table 4-24 are used in Tables 4-26 and 4-27. Table 4-26 provides the MSA (Measurement of Sampling Adequacy) for each of the variables. It also provides the communality estimates for each variable. The MSA of each of the variables, as well as the overall MSA of 0.867, is above .8 which indicates marvellous sampling adequacy. In addition, only one factor had an eigenvalue higher than 1. This indicated 1 factor which was identified as the success of the project. The communalities indicate the percentage of variance explained by the identified factor. The final communality estimate total was 3.67 with the 1 factor explaining 61.19% of the variance of the variables.

Table 4-26: **MSA and communality of the variables for success of the project**

Variable	MSA	Communality
C9_1	0.849	0.664
C9_2	0.841	0.612

C9_3	0.896	0.572
C9_4	0.915	0.472
C9_5	0.859	0.633
C9_6	0.861	0.719

Table 4-27 provides the MSA (Measurement of Sampling Adequacy) for each of the variables. It also gives the communality estimates for each variable. The MSA of each of the variables is greater than 0.8 which indicates marvellous sampling adequacy. In addition, only one factor had an eigenvalue higher than 1. This indicated 1 factor which was identified as the success of the system. The communality in Table 4-27 indicates the percentage of variance that is explained by the identified factor. The final communality estimate total was 6.29 with the 1 factor explaining 57.20% of the variance of the variables.

Table 4-27: MSA and communality of the variables for the success of the system

Variable	MSA	Communality
C10_1	0.941	0.603
C10_2	0.943	0.626
C10_3	0.909	0.576
C10_4	0.923	0.406
C10_5	0.968	0.550
C10_6	0.934	0.621
C10_7	0.933	0.635
C10_8	0.945	0.345
C10_9	0.949	0.725
C10_10	0.878	0.577
C10_11	0.894	0.629

These two factors, the success of the system and the success of the project, were further used during the analysis to determine if any component influenced the success of the project or system. In addition, the mean value for these factors are as follows:

- Success of the project = 3.81; and
- Success of the system = 3.92.

The test for reliability for both the factor analysis of the success of the system as well as the success of the project was done through the calculation and interpretation of the Cronbach coefficient alpha (∝). This value (indicated in orange) will show the correlation between the applicable questions. Table 4-28 reports that the success of the system indicated an excellent reliability ($Cronbach's \propto > 0.9$) and the success of the project indicated a good reliability ($Cronbach's \propto > 0.8$).

Table 4-28: Cronbach coefficient alpha for the success of the system and project

Factor	**Cronbach coefficient alpha**
Success of the system	0.917
Success of the project	0.864

4.2.3 REQUIREMENTS ENGINEERING PROCESS

This section will report the results for the RE process. The questions used for the data analysis are located in the questionnaire (Appendix B) under the sub-section – *The RE process* (reported in Section 4.2.3.1) and *Changes in the requirements* (reported in Section 4.2.3.2) under Section D – *Requirements Engineering* of the questionnaire. These questions, unrelated to the use of GORE methods or traditional RE, were asked to identify general aspects regarding RE.

4.2.3.1 THE PHASES

Table 4-29 indicates the frequencies (F) and means for each of the phases for Group 1. All of the mean values are greater than 3 which indicates that the participants agreed that it was easy to complete the phases. Table 4-30 indicate the frequencies (F) and percentages (%) of Group 1's responses to the different phases of the RE process. A scale (1 being "totally disagree" and 5 being "totally agree") was used to indicate that it was easy to complete each of the phases. The neutral column was omitted in Table 4-30 so that only the applicable results would be reported. The orange colour in Table 4-30 is used to indicate when a higher percentage of participants agreed that the phase was easy to complete. The requirements elicitation phase was shown to be the most difficult with 19.05% (percentage of scale 1 and 2) indicating they did not agree that it was easy (indicated in red), and 45.23% (percentage of scale 4 and 5) indicating that they agreed that it was easy.

Table 4-29: Frequencies and means for the RE process phases for Group 1

Phase	F	Mean
Requirements Elicitation	42	3.36
Requirements Analysis	42	3.69
Requirements Specification	42	3.76
Requirements Validation	42	3.67

Table 4-30: Frequencies and percentages for the RE process phases for Group 1

	Requirements elicitation		Requirements analysis		Requirements specification		Requirements validation	
Scale	**F**	**Percentage**	**F**	**Percentage**	**F**	**Percentage**	**F**	**Percentage**
Totally Disagree	1	2.38%	2	4.76%	2	4.76%	2	4.76%
Mostly Disagree	7	16.67%	3	7.14%	3	7.14%	4	9.52%
Mostly Agree	14	33.33%	16	38.10%	19	45.24%	18	42.86%
Totally Agree	5	11.90%	10	23.81%	10	23.81%	9	21.43%

The following part report on the difference between Group 1 and Groups 2. Table 4-31 indicates whether or not the answers provided by Group 1 and Group 2 regarding the phases of RE, were different. The effect size was calculated, as described in Section 3.5.3.8, for each of the questions. The questions are related to the phases of the RE process, which are described in the first column. Using the criteria also discussed in Section 3.5.3.8, no value indicated statistical significance. Table 4-31 thus indicates that both Group 1 and Group 2 gave the same answer with the regard to the RE process phases.

Table 4-31: Effect sizes for the RE process phases

Phase	Group	N	Mean	Std. Dev	$p-value^{\Delta}$	$d-value$
Requirements Elicitation	Group 1	42	3.3571	0.9833	0.5617	0.10
	Group 2	114	3.2544	0.9576		
	Group 1	42	3.6905	1.0704	0.2778	0.19

Requirements Analysis	Group 2	114	3.4825	1.0065		
Requirements Specification	Group 1	42	3.7691	1.0548	0.0912	0.31
	Group 2	114	3.4386	1.0222		
Requirements Validation	Group 1	42	3.6667	1.0754	0.1298	0.27
	Group 2	114	3.3772	0.9629		

$\Delta - when\ random\ sampling\ is\ assumed$

4.2.3.2 CHANGES IN THE REQUIREMENTS

The second part of the RE section on the questionnaire was related to changes in the requirements. Table 4-32 indicates the frequencies and percentages of Group 1's agreement level on statements regarding the changes in requirements. A scale (1 being "totally disagree" and 5 being "totally agree") was used to indicate to what level they agreed with the statement. The neutral column was omitted in Table 4-32 so that only the applicable results would be reported. Mean values greater than 3 (indicated in dark green) indicate that the participants mostly agreed with the statement while mean values below 3 (indicated in light green) indicated that the participants didn't agree with the statement. The yellow indicates neutral responses. The dark orange colour in Table 4-32 is used to indicate when a higher percentage of participants agreed with the statement while the light orange colour is used to indicate if a higher percentage of the participants disagreed with the statement. The red colour indicate scale values that weren't selected. The participants mostly agreed that problems regarding communication (78.80%), misunderstandings between stakeholders (59.53%), budget (19.04%) and scheduling concerns (45.24%), are all contributing to the changes in requirements. In addition, the participants indicated that changes in the requirements changed the budget (47.61%) as well as the schedule (73.81%) of the project. Finally, 50% of the participants indicated that GORE method use improved the ability to manage changes in requirements.

Table 4-32: Means, frequencies and percentages for the changes in requirements for Group 1

Question	Mean	Property	Totally disagree	Mostly disagree	Mostly agree	Totally agree
Communication problems	3.74	Frequency	-	5	26	5
		Percentage	-	11.90%	61.90%	11.90%
Stakeholder misunderstanding	3.5	Frequency	3	4	19	6
		Percentage	7.14%	9.52%	45.24%	14.29%

The budget	2.62	Frequency	9	10	4	4
		Percentage	21.43%	23.81%	9.52%	9.52%
The schedule	3.33	Frequency	4	6	10	9
		Percentage	9.52%	14.29%	23.81%	21.43%
The development team	3.00	Frequency	4	10	6	6
		Percentage	9.52%	23.81%	14.29%	14.29%
Wrong elicitation technique	2.71	Frequency	8	10	6	4
		Percentage	19.05%	23.81%	14.29%	9.52%
Changed the budget	3.40	Frequency	2	4	15	5
		Percentage)	4.76%	9.52%	35.71%	11.90%
Changed the schedule	3.90	Frequency	2	-	20	11
		Percentage	4.76%	-	47.62%	26.19%
Low number of changes	2.88	Frequency	7	11	10	5
		Percentage	16.67%	26.19%	23.81%	11.90%
Easy to manage	3.56	Frequency	1	2	13	8
		Percentage	2.38%	4.76%	30.95%	19.05%

Table 4-33 indicates the effect sizes for each of the statements (see Table 4-32) regarding the changes in requirements. The first six rows are related to the reasons for the changes in requirements and the following two are related to the effect of requirement changes. Using the criteria also discussed in Section 3.5.3.8, one component indicated statistical significance. The management of changes in requirements was shown to be easier when using GORE than when using traditional RE. There was a medium ($d \geq$ **0.50**) effect with $d \geq$ **0.10*** and p indicating statistical significance with the value of $p \leq$ **0.05****. These values are indicated in green in Table 4-33.

Table 4-33: Effect sizes for the changes in requirements

Question	**Group**	**F**	**Mean**	**Std. Dev**	$p-value^{\Delta}$	$d-value$
Communication problems	Group 1	42	3.7381	0.8281	0.1571	0.22
	Group 2	114	3.5088	1.0411		
Stakeholder misunderstanding	Group 1	42	3.5000	1.8076	0.7919	0.05
	Group 2	114	3.4474	1.1374		
The budget	Group 1	42	2.6190	1.2088	0.9862	0.00
	Group 2	114	2.6228	1.1779		
The schedule	Group 1	42	3.3333	1.2429	0.2642	0.20

	Group 2	114	3.0877	1.1096		
The development team	Group 1	42	3.0000	1.1687	0.3057	0.18
	Group 2	114	2.7807	1.2029		
Wrong elicitation technique	Group 1	42	2.7143	1.2155	0.1533	0.26
	Group 2	114	2.4035	1.1267		
Changed the budget	Group 1	42	3.4048	0.9892	0.1853	0.21
	Group 2	114	3.1491	1.2354		
Changed the schedule	Group 1	42	3.9048	0.9579	0.0544	0.30
	Group 2	114	3.5439	1.1910		
Low number of changes	Group 1	42	2.8810	1.2917	0.7162	0.07
	Group 2	114	2.9649	1.2260		
Easy to manage	Group 1	42	3.5952	0.9386	0.0098*	0.50**
	Group 2	114	3.1404	0.9855		

$\Delta - when\ random\ sampling\ is\ assumed$

$* p \leq 0.05$

$** d - Medium\ effect\ size$

4.2.4 RE AND GORE IMPLEMENTATION

The final section of this chapter will provide results regarding the implementation of GORE methods and traditional Requirements Engineering. The first section will provide results for requirements elicitation tasks while the second section will look at the requirements elicitation techniques. The last section will discuss the overall implementation of traditional Requirements Engineering and GORE methods.

4.2.4.1 REQUIREMENTS ELICITATION TASKS

This section will provide the results that were related to the elicitation process, the implementation of requirements elicitation and communication during requirements elicitation.

4.2.4.1.1 REQUIREMENT ELICITATION TASKS

The first results, presented in Table 4-34, indicate the frequencies and mean values of the participant's level of agreement with the statement that it was easy to complete the specified tasks. The frequencies and percentages in Table 4-35 indicate the participant's level of agreement to the statement that it was easy to complete the specified tasks. A scale (1 being "totally disagree" and 5 being "totally agree") was used to indicate to what level they agreed with the statement that it was easy to complete the specific task. Mean values greater than 3 (indicated in green) show that the participants mostly agreed that it was easy to complete the specified tasks. The orange colour in Table 4-35 is used to indicate when a higher percentage of participants agreed with the statement. The neutral column was omitted in Table 4-35 so that only the applicable results would be reported. Both Group 1 and Group 2 were used to complete the table. Both the groups indicated that all of the specified tasks were easy to complete.

Table 4-34: Frequencies and means of completing elicitation tasks

Task	F	Mean
Create an initial scope document	156	3.48
Identification of the actual requirements	156	3.51
Prioritise and determine resales	156	3.50
Review and inspect artefacts	156	3.46

Table 4-35: Frequencies and percentages of completing elicitation tasks

	Create an initial scope document		Identification of the actual requirements		Prioritise and determine releases		Review and inspect artefacts	
Scale	**F**	**Percentage**	**F**	**Percentage**	**F**	**Percentage**	**F**	**Percentage**
Totally disagree	8	5.13%	5	3.21%	7	4.49%	6	3.85%
Mostly disagree	15	9.62%	19	12.18%	14	8.97%	12	7.69%
Mostly disagree	55	35.26%	59	37.82%	61	39.10%	59	37.82%
Totally disagree	25	16.03%	25	16.03%	23	14.74%	18	11.54%

4.2.4.1.2 ELICITATION TECHNIQUE IMPLEMENTATION

Group 1 and Group 2 are both reported in Table 4-36. Table 4-36 indicates the means, frequencies (F) and percentages of the participant's level of agreement to the statements related to the implementation and use of the elicitation technique. A scale (1 being "totally disagree" and 5 being "totally agree") was used to indicate to what level they agree with the statement. The neutral column was omitted in Table 4-36 so that only the applicable results would be reported. Mean values greater than 3 (indicated in dark green) indicates that the participants mostly agreed with the statement. Mean values less than 2 (indicated in light green) indicates that the participants mostly disagreed with the statement. The dark orange colour in Table 4-36 is used to indicate when a higher percentage of the participants agreed with the specific statement while the light orange colour is used to indicate when a higher percentage disagreed with the specific statement. The participants indicated that the selected techniques were easy to implement (53.59%) although some (28.20%) required extra knowledge. In addition, 30.13% of the participants indicated that the techniques had changed during the development while 30.13% of the participants indicated that the techniques hadn't change. 32.05% of the participants indicated that selected techniques were time-consuming while 48.21% of the participants indicated that the selected technique required extra resources. In addition, 36.54% indicated that the selected techniques didn't require changes in the budget. Finally, 19.88% of the participants indicated that the techniques were not sufficient in identifying all the requirements while 42.31% indicated that the techniques were sufficient.

Table 4-36: Means, frequencies and percentages of the elicitation technique implementation

Statement	**Mean**	**Property**	**Totally disagree**	**Mostly disagree**	**Mostly agree**	**Totally agree**
Easy to implement	3.41	Frequency	4	13	51	17
		Percentage	2.56%	8.33%	32.69%	10.90%
No extra knowledge required	3.06	Frequency	10	34	35	14
		Percentage	6.41%	21.79%	22.44%	8.97%
Techniques changed during development	2.97	Frequency	15	32	36	11
		Percentage	9.62%	20.51%	23.08%	7.05%
Implementation is time Consuming	3.05	Frequency	11	29	41	9
		Percentage	7.05%	18.59%	26.28%	5.77%
Extra resources required for implementation	2.95	Frequency	15	30	36	8
		Percentage	9.62%	19.23%	43.08%	5.13%
	2.71	Frequency	25	32	28	5

Technique required changes in the budget		Percentage	16.03	20.51	17.95	3.21
The technique was sufficient	3.24	Frequency	9	22	54	12
		Percentage	5.77	14.10	34.62	7.69

4.2.4.1.3 COMMUNICATION DURING REQUIREMENTS ELICITATION

Communication during requirements elicitation was analysed with the use of factor analysis. Table 4-37 indicates the variables and their corresponding questions that were used during the analysis. The questions used are located in Annexure B under the sub-section – *Communication during the requirements elicitation* in Section D – Requirements Engineering of the questionnaire.

Table 4-37: Values of the variables related to questions (Communication)

Variable	Question
D.2_12	There was a need for frequent communication
D.2_13	There was a need for communication between different organisational levels
D.2_14	The degree of communication influences the chosen requirements elicitation techniques
D.2_15	Communication between the different stakeholders was difficult during the requirements elicitation phase
D.2_16	Problems with communication resulted in incomplete or faulty requirements
D.2_17	Overall, communicating requirements is difficult.

Table 4-38 indicates the means, frequencies(F) and percentages of the responses level of agreement to statements related to communication. Mean values greater than 3 indicate that the participants mostly agreed (indicated in light green) while mean values greater than 4 indicate that the participants totally agreed (indicated in dark green). The orange colour in Table 4-38 is used to indicate if a higher percentage of the participants agreed with the specific statement. The variables described in Table 4-37 is used in Table 4-38. The participants indicated that there was a need for frequent communication (D.2_12: 79.49%) as well as a need for communication between different levels within in the organisation (D.2_13: 71.15%). 76.03% (D.2_14) of the participants indicated that the selection of the elicitation techniques is influenced by the degree of communication. The participants indicated that communication between stakeholders were difficult during the requirements elicitation phase (D.2_15: 42.95%), communication problems lead to faulty requirements (D.2_16: 45.51%), and that it is difficult to communicate requirements (D.2_17: 76.16%)

Table 4-38: The means, frequencies and percentages of the communication during requirements elicitation

Method	Mean	F	Totally disagree	Mostly disagree	Mostly agree	Totally agree
D.2_12	4.10	156	1.92%	1.92%	42.95%	36.54%
D.2_13	3.88	156	3.85%	6.41%	40.38%	30.77%
D.2_14	3.85	156	1.28%	3.21%	41.03%	25.00%
D.2_15	3.24	156	7.05%	14.74%	32.69%	10.26%
D.2_16	4.29	156	8.33%	13.46%	32.05%	13.46%
D.2_17	4.24	156	5.77%	21.79%	64.62%	11.54%

The variables listed in Table 4-37 is used in Table 4-39 and Table 4-40. Table 4-39 provides the MSA (Measurement of Sampling Adequacy) for each of the variables. It also gives the communality estimates for each variable. Table 4-39 indicates that the MSA for each of the variables greater than 0.5, which is acceptable. However, the calculation of the eigenvalue (see Section 3.5.3.6) revealed two factors, because two values were greater than 1. Thus further analysis was required and the use of rotation indicated that the questions were divided among the two factors.

Table 4-39: MSA and communality of the variables for question D.2

Variable	MSA	Communality
D2_12	0.588	0.760
D2_13	0.764	0.619
D2_14	0.628	0.752
D2_15	0.707	0.761
D2_16	0.757	0.737
D2_17	0.619	0.770

Rotation was used to produce Table 4-40. Each of the values in Table 4-40 indicates the factor's contribution to the variance of each of the variables. Factor 1 does not have any effect on variables D.2_12 – D.14 and factor 2 does not have any effect on variables D.2_15 – D.2.17. Thus, the following can be concluded:

- Factor 1 – Has an effect on the following: Communication between the different stakeholders was difficult during the requirements elicitation phase. Problems with communication resulted in incomplete or faulty requirements. Overall, communication requirements are difficult. These statements are all related to this factor, which indicates difficulty of communication.

- Factor 2 – There was a need for frequent communication. There was a need for communication between different organisational levels. The degree of communication influences the chosen requirements elicitation technique. These statements are all related to this factor, which indicates need for communication.

Thus, Table 4-40 indicated that the questions related to communication during the requirements elicitation phase can be divided into two factors, the need and degree of communication (indicated in dark green), and the difficulty of communication (indicated in light green).

Table 4-40: Result of rotation indicating the factor pattern for two factors

Variable	Difficulty of Communication (Factor 1)	Need for frequent communication (Factor 2)
D.2_17	0.918	
D.2_16	0.837	
D.2_15	0.786	
D.2_12		0.907
D.2_13		0.862
D.2_14		0.686

In addition, the mean values for the factors are as follows:

- Difficulty of communication = 3.26; and
- Need for frequent communication = 3.94.

The mean values indicate that the participants would mostly agree that there is a need for frequent communication and that communication is difficult. The test for reliability for both the factors regarding communication was done by calculating and interpreting the Cronbach coefficient alpha ($\propto$). This value (showed in orange) will indicate the correlation between the applicable questions. Table 4-41 reports that the need for communication indicated an acceptable reliability ($Cronbach's \propto > 0.7$) and the difficulty of communication indicated a good reliability ($Cronbach's \propto > 0.8$). Both these values thus indicated that the tests done to determine these two factors are reliable.

Table 4-41: Cronbach coefficient alpha for the need and difficulty of communication

Factor	Cronbach coefficient alpha
Need for communication	0.775
Difficulty of communication	0.828

4.2.4.2 REQUIREMENTS ELICITATION TECHNIQUES

This section will provide the results of the analysis of the requirements elicitation techniques. The first part will provide the results regarding the success of the system and project while the second part will report on the most popular techniques used.

4.2.4.2.1 POPULAR REQUIREMENTS ELICITATION TECHNIQUES

Table 4-42 indicates the extent of implementation for each elicitation technique. A scale (1 being “not at all” and 5 being “to a greater extent”) was used to indicate to what extent the elicitation techniques had been implemented. The neutral column was omitted in Table 4-42 so that only the applicable results would be reported. Mean values greater than 3 (indicated in dark green) indicates that the elicitation technique was implemented to some extent while values less than 3 (indicated in light green) indicates that the elicitation technique was implemented to a lesser extent. Furthermore, Table 4-42 provides the results, for which the frequency (F) as well as the extent of implementation (in percentage) are reported.

The following techniques were implemented to some extent (indicated in dark orange).

- Interviews (53.20%), task analysis (53.85%), domain analysis (50.64%), analysis of existing documents, manuals and existing systems (66.67%), group work (51.92%), brainstorming (62.28%), Joint Application Development (36.54%), requirements workshops (53.85%), prototyping (44.23%), use cases (55.77%), scenarios (58.33%), observations (42.95%).

The following techniques were implemented to a lesser extent or not at all (indicated in light orange).

- Surveys (59.61%), questionnaires (56.41%), card sorting (54.48%), protocol analysis (41.66%), ethnography (52.57%).

Surveys as well as questionnaires are both techniques that were implemented to a lesser extent. This can indicate how inefficient these two techniques are regarding time. The poor response rate, as experienced in this study, can also be identified as a reason for the low implementation.

Table 4-42: Frequencies, means and percentages of the implementation extent of the requirement elicitation techniques

Method	F	Mean	Not at all	To a lesser extent	To some extent	To a greater extent
Interviews	156	3.24	21.15%	7.05%	33.33%	19.87%
Surveys	156	2.15	46.79%	12.82%	11.54%	5.13%
Questionnaires	156	2.22	44.87%	11.54%	13.46%	5.13%
Task Analysis	156	3.33	14.10%	8.97%	37.82%	16.03%
Domain Analysis	156	3.28	14.10%	10.26%	35.26%	15.38%
Analysis of existing documents, manuals and existing systems	156	3.74	9.62%	4.49%	35.26%	31.41%
Card sorting	156	2.17	45.51%	8.97%	10.26%	3.21%
Protocol Analysis	156	2.54	33.97%	7.69%	17.95%	5.77%
Group work	156	3.23	16.03%	11.54%	37.18%	14.74%
Brainstorming	156	3.57	12.18%	6.41%	37.28%	25.00%
Joint Application Development (JAD)	156	2.91	23.08%	9.62%	26.28%	10.26%
Requirements workshops	156	3.32	18.59%	9.62%	28.85%	25.00%
Prototyping	156	3.12	21.15%	8.33%	26.28%	17.95%
Use cases	156	3.48	12.18%	8.97%	30.13%	25.64%
Scenarios	156	3.50	9.62%	7.05%	39.74%	18.59%
Ethnography	156	2.25	41.67%	10.90%	14.10%	2.56%
Observations	156	3.03	21.15%	9.62%	31.41%	11.54%

Table 4-43 and Table 4-44 provide the top 5 requirements elicitation techniques used for GORE and traditional RE. To list the relevant techniques, techniques with a mean value between 2 and 3 were ignored due to mean value 3 indicating neutral implementation. Table 4-43 lists the top 5 techniques used when implementing GORE. The mean values for all the techniques are greater than 3 which indicates an implementation of the technique to some extent.

Table 4-43: Top 5 requirement elicitation techniques ranked by mean for Group 1.

Technique	GORE	
	N	Mean
1. Analysis of existing documents, manuals and existing systems	42	3.98
2. Use case	42	3.89
3. Brainstorming	42	3.76
4. Scenarios	42	3.62
5. Requirements workshop 5. Task analysis	42	3.57 3.57

Table 4-44 indicates the top 5 techniques used when implementing traditional RE. Values greater than 2 and less than 3 were omitted as they indicated a neutral answer. The mean values for all the techniques are greater than 3 which indicates an implementation of the technique to some extent. Analysis of existing documents, manuals and existing systems were the most popular for both Group 1 (3.98) and Group 2 (3.66), while the use of brainstorming and use cases are evident in both groups.

Table 4-44: Top 5 requirement elicitation techniques ranked by mean for Group 2.

Technique	Traditional RE	
	N	Mean
1. Analysis of existing documents, manuals and existing systems	114	3.66
2. Brainstorming	114	3.50
3. Scenarios	114	3.46
4. Use cases	114	3.35
5. Domain analysis	114	3.29

4.2.4.2.2 REQUIREMENTS ELICITATION AND THE SUCCESS OF THE PROJECT AND SYSTEM

The factors related to the success of the system and the success of the project calculated in Section 4.2.2.6 were used during this analysis. The analysis was used to identify if there is any correlation between the specific requirement elicitation technique and the success of the project and system. Table 4-45 indicates the correlation between the RE elicitation techniques and the success of the project and success of the system for Group 1. The elicitation techniques used in

GORE is the focal point, thus the omission of Group 2. The following information is extracted from the Table 4-45.

- The use of task analysis, domain analysis, and the analysis of existing documents, manuals and existing systems all indicate a correlation with a medium effect size that is statistically significant regarding the success of the project. Thus, the implementation of these methods indicated better success of the project. These values are indicated in light orange.
- The use of surveys, questionnaires, use cases, JAD, and the analysis of existing documents, manuals and existing systems all indicate a correlation with a medium effect size that is statistically significant regarding the success of the system. Task analysis and domain analysis indicate a correlation with a high effect size that is statistically significant regarding the success of the system. Thus, the implementation of these methods resulted in better success of the system. These values are indicated in dark orange.

Table 4-45: Pearson's correlation between the requirement elicitation techniques and the success of the project and system for Group 1

	Success of the project		**Success of the system**	
Techniques	**r – value**	**$p-value^{\Delta}$**	**r – value**	**$p-value^{\Delta}$**
Interviews	0.021	0.893	0.182	0.249
Surveys	0.084	0.598	0.321*	0.038***
Questionnaires	0.248	0.113	0.435*	0.004***
Task analysis	0.454*	0.002***	0.552**	0.0002***
Domain analysis	0.381*	0.013***	0.588**	<.0001***
Analysis of existing documents, manuals and existing systems	0.359*	0.020***	0.414*	0.0064***
Card sorting	0.197	0.212	0.252	0.107
Protocol analysis	0.218	0.166	0.144	0.363
Group work	0.236	0.133	0.164	0.300
Brainstorming	0.190	0.229	0.059	0.713
Joint Application Development (JAD)	0.180	0.253	0.321*	0.038***
Requirements workshops	-0.035	0.846	0.136	0.392
Prototyping	0.053	0.736	0.138	0.383
Use-cases	0.299	0.054	0.322	0.037
Scenarios	0.249	0.112	0.249	0.112
Ethnography	0.093	0.557	0.236	0.133
Observations	0.067	0.676	0.269	0.086

$\Delta - when\ random\ sampling\ is\ assumed$

$* r \geq 0.30 - medium\ effect\ size$

$** r \geq 0.50 - large\ effect\ size$

$*** p \leq 0.05 - statistical\ significane$

4.2.4.3 IMPLEMENTATION STRICTNESS AND INTENSITY

The participants were asked to indicate the level of strictness and level of intensity when implementing GORE and traditional RE. To analyse the strictness and intensity, the correlation between (1) the strictness and intensity of implementation and (2) the success of the project and system was calculated. First the descriptive results will be provided, followed by the aforementioned analysis.

4.2.4.3.1 DESCRIPTIVE RESULTS FOR IMPLEMENTATION STRICTNESS AND INTENSITY

The correlations for Group 1 and Group 2 were measured independently. This means, only the participants in Group 1 were measured with strictness and intensity of implementation of GORE methods (see Section E – Goal Oriented Requirements Engineering (GORE) usage in Annexure B) and only the participants in Group 2 were measured with strictness and intensity of implementation of traditional RE (see Section F – Traditional Requirements Engineering (RE) usage in Annexure B).

The respondents were asked to indicate, on a scale of 1 to 10, the implementation intensity and implementation strictness of GORE methods (with 1 being “almost no intensity/strictness” and 10 being “very intense/strict”). Table 4-46 provides the frequencies (F) and percentages for each of the scale levels for Group 1 regarding the implementation intensity and strictness. The GORE methods were implemented at a medium to high (scale level 5 to 10) intensity level of 61.76% in Group 1. The GORE methods were implemented at a medium to high (scale level 5 to 10) strictness level of 67.64% in Group 1. The red cells in Table 4-46 indicate scale levels that didn’t receive any values while light orange indicates less than medium (scale level 4) to small intensity and strictness implementation levels. The dark orange indicates medium to high intensity and strictness implementation levels.

Table 4-46: Frequencies and percentages of the implementation intensity and strictness for Group 1

	Intensity		Strictness	
Scale	**F**	**Percentage**	**F**	**Percentage**
1	8	23.53%	4	11.76%
2	0	0.00%	3	8.82%
3	0	0.00%	1	2.94%
4	5	14.71%	3	8.82%
5	7	20.59%	7	20.59%
6	5	14.71%	3	8.82%
7	2	5.88%	1	2.94%
8	3	8.82%	8	23.53%
9	2	5.88%	1	2.94%
10	2	5.88%	3	8.82%

Table 4-47 provides the frequencies (F) and percentages for each of the scale levels for Group 2, regarding the implementation intensity and strictness. Traditional RE were implemented at a medium to high (scale level 5 to 10) intensity level of 62.69% in Group 2. The GORE methods were implemented at a medium to high (scale level 5 to 10) strictness level of 58.46% in Group 2. The light orange cells in Table 4-47 indicate scale levels less than medium (scale level 4) to small intensity and strictness implementation levels. The dark orange indicates medium to high intensity and strictness implementation levels.

Table 4-47: Frequencies and percentages of the implementation intensity and strictness for Group 2

	Intensity		Strictness	
Scale	**F**	**Percentage**	**F**	**Percentage**
1	13	19.40%	12	18.46%
2	4	5.97%	3	4.62%
3	3	4.48%	5	7.69%
4	5	7.46%	7	10.77%
5	12	17.91%	10	15.38%
6	7	10.45%	8	12.31%
7	4	5.97%	6	9.23%
8	9	13.43%	6	9.23%
9	3	4.48%	3	4.62%
10	7	10.45%	5	7.69%

Table 4-48 indicates the mean value of the implementation intensity and strictness for Group 1 and Group 2. The mean values of Group 1 (shown in yellow) indicated that the implementation intensity of GORE methods was at a medium level (scale level 5) and the implementation strictness at above medium (scale level 6). The mean values of Group 2 (shown in blue) indicated that the implementation intensity and strictness of traditional RE was above medium level (scale level 6).

Table 4-48: Mean values of the implementation intensity and strictness for Group 1 and Group 2.

	Mean value	
Property	**Group 1**	**Group 2**
Intensity	4.97	5.02
Strictness	5.23	5.21

The result from the descriptive statistics in this section indicated that Group 1 and Group 2 both had a medium to high level (Group 1 = 61.75% and 67.64%, Group 2= 62.69% and 58.46%) of the implementation intensity and strictness.

4.2.4.3.2 GORE

Table 4-49 indicates the correlation between the intensity and strictness of the implementation of GORE and the success of the project and success of the system. The following information can be extracted from Table 4-49:

- There exists a correlation with a high effect size that is statistically significant, between (1) the success of the project and system and (2) the intensity of the implementation of GORE. The sample indicates improved success both for the project and system when the GORE method was implemented more intensively (indicated with in green).
- There exists a correlation with a high effect size that is statistically significant between (1) the success of the project and system and (2) the strictness of the implementation of GORE. The sample indicates improved success both the project and system when the GORE method was implemented more strictly (indicated in light green).

Table 4-49: **Pearson's correlation coefficients between the success of the system/ project and the intensity/ strictness of implementation of GORE methods.**

	Success of the project		Success of the system	
Property	r – **value**	$p - value^{\Delta}$	r – **value**	$p - value^{\Delta}$
Intensity	0.53486*	0.0011**	0.61535*	0.0001**
Strictness	0.49232*	0.0031**	0.54956*	0.0008**

$\Delta - when\ random\ sampling\ is\ assumed$

$* \, r \geq 0.50 - large\ effect\ size$

$** \, p \leq 0.05 - statistical\ significane$

4.2.4.3.3 TRADITIONAL RE

The traditional RE group's correlation results are provided in Table 4-50. Table 4-50 indicates the correlation between (1) the intensity and strictness of the implementation of traditional RE and (2) the success of the project and success of the system. The following information is extracted from the above table.

- There exists a correlation with a medium effect size that is significant between (1) the success of the system and (2) the strictness of the implementation of traditional RE (indicated in light green).

Table 4-50: **Pearson's correlation coefficients between the success of the system/ project and the intensity/ strictness of implementation of traditional RE.**

	Success of the project		Success of the system	
Property	r – **value**	$p - value^{\Delta}$	r – **value**	$p - value^{\Delta}$
Intensity	0.02804	0.8218	0.10050	0.4184
Strictness	0.15168	0.2278	0.26884*	0.0304**

$\Delta - when\ random\ sampling\ is\ assumed$

$* \, r \geq 0.30 - medium\ effect\ size$

$** \, p \leq 0.05 - statistical\ significane$

4.2.4.4 NON-GORE PARTICIPANT REVIEW

This section will provide the results showing why GORE methods are not implemented. The questions used for the data analysis are located in Annexure B under sub-section – *To what extent do you agree with the following statements regarding traditional RE and not the usage of*

GORE methods and under Section F – *Traditional Requirements Engineering (RE) usage* of the questionnaire. Only the responses from Group 2 were used as the questions were specifically aimed at the participants who do not use GORE.

Table 4-51 indicates the means, frequencies (F) and percentages of the participant's level of agreement to the statements related to non-GORE usage. A scale (with 1 being "totally disagree" to 5 being "totally agree") was used to indicate the level at which they agree with the statement. The neutral column was omitted in Table 4-51 so that only the applicable results would be reported. Mean values greater than 3 (indicated in green) indicates that the participants mostly agreed with the statement. The orange colour in Table 4-51 is used to indicate when a higher percentage of the participants agreed with the specific statement while red is used to indicate scale levels that didn't receive any answers. The participants mostly agreed to all of the specified statements with most of the participants (63.33%) agreeing that GORE methods are unknown. However, most of the users indicated a neutral response (scale level 3) to the statements or didn't answer. This can indicate the sample's lack of knowledge about GORE methods. Due to the low number of responses, no definite reason can be identified for non-GORE usages.

Table 4-51: Mean, frequency and percentages of the level of agreement regarding non-GORE usage as indicated by Group 2

Statements	Mean	Property	Totally disagree	Mostly disagree	Mostly agree	Totally agree
GORE methods are unknown	3.78	Frequency	4	-	21	17
		Percentage	6.67%	-	35.00%	28.33%
GORE methods are too difficult to implement	3.05	Frequency	4	-	5	3
		Percentage	6.90%	-	8.62%	5.17%
Will require extra training	3.20	Frequency	3	-	9	4
		Percentage	5.45%	-	16.36%	7.27%
Traditional RE is sufficient	3.13	Frequency	5	-	19	4
		Percentage	9.26%	-	35.19%	7.41%
Does not have the required knowledge	3.39	Frequency	4	-	14	9
		Percentage	6.56%	-	22.95%	14.75%
	3.05	Frequency	6	-	5	4

Not suitable for the development environment		Percentage	11.76%	-	9.80%	7.84%
Management prevents/prohibits the use or change to GORE/other methods	3.16	Frequency	6	-	5	5
		Percentage	10.91%	-	9.09%	9.09%
Uncertainty about benefits	3.54	Frequency	5	-	10	5
		Percentage	8.33%	-	16.67%	8.33%

The final table, Table 4-52, indicates the means, frequencies (F) and percentages of the participant's level of agreement to statements regarding the sufficiency of traditional RE. The orange colour in Table 4-52 is used to indicate when a higher percentage of the participants agreed with the specific statement while red is used to indicate scale levels that didn't received any answers. The participants mostly agreed to all of the specified statements which indicates that the participants see tradition RE as sufficient. However, most of the users indicated a neutral response (scale level 3) to the statements or didn't answer. Due to the low number of responses, no definite component can be identified in terms of the sufficiency of traditional RE.

Table 4-52: Mean, frequency and percentages of the level of agreement regarding the sufficiency of traditional RE as indicated by Group 22

Statements	Mean	Property	Totally disagree	Mostly disagree	Mostly agree	Totally agree
Sufficient for phase: requirements elicitation	3.66	F	2	-	21	11
		%	3.39	-	35.59%	18.64%
Sufficient for phase: requirements analysis	3.64	F	4	-	25	10
		%	6.90	-	43.10%	17.24%
Sufficient for phase: requirements specification	3.51	F	4	-	19	9
		%	7.02	-	33.33%	15.79%
Sufficient for communicating requirements	3.63	F	2	-	26	8
		%	3.33	-	43.33%	13.33%
Sufficient for identifying all requirements	3.67	F	3	-	27	9
		%	3.28	-	44.26%	14.75%
Sufficient for keeping requirements consistent	3.64	F	2	-	27	7
		%	3.45	-	46.55%	12.07%
	3.60	F	3	-	27	7

Sufficient for establishing and maintaining an agreement with the customer and users of the requirements		%	5.08	-	45.76%	11.86%
Sufficient for management and tracking of changes in the requirements	3.60	F	3	-	23	9
		%	5.08	-	38.98%	15.25%
Sufficient for Identifying new, evolving requirements	3.53		5	-	24	9
			8.33	-	40.00%	15.00%

4.3 EVALUATION OF RESEARCH OBJECTIVES

The purpose of the Section 4.2 was to present the analysed data collected for the study. The data analysis thus provides results that can be used to complete the research aims and objectives as defined in Section 1.3. This section will discuss how the research aims and objectives were met by linking the results of the questionnaire and information in the literature to each of the objectives. Each of the aims and objectives will be discussed under the appropriate heading.

4.3.1 IDENTIFY THE CURRENT STATE OF GORE METHOD USE

The first objective was to identify the current state of GORE method use. To complete this objective, a review of current literature was needed. Together with the literature review, data from analysed questionnaires sent out to participants in the IT industry was used. Each of these two sources will be explained next.

4.3.1.1 LITERATURE REVIEW

A literature review was needed to identify the current use of GORE methods because this would provide information that is not obtainable through the questionnaires alone. Furthermore, the review of the literature also provided information that contributed to the questions asked in the questionnaire. The part of the literature review most applicable to this objective is Section 2.2.4.2.

First, by identifying the different GORE methods that are available it was possible to give an indication of what methods are used. Table 2-8 in Section 2.2.4.1, which is a summary of the methods found in the literature, indicated that there many methods are available. In addition to this, Table 2-9 in Section 2.2.4.2 indicates which method is most applicable to which phase of the RE process. Aljahdali (2011:311) also indicated in Table 2-9 what activity within each of the phases should be done by the GORE methods. Horkoff and Yu (2011:678) provided an extensive list of GORE methods found in the literature in Table 2-10. These GORE methods are illustrated with certain characteristics such as the type of goals supported, dependencies, etc. This is an indication of what the GORE methods can provide when implemented. Horkoff and Yu (2011:678) also provided Table 2-11 and Table 2-12 with more descriptions of current GORE methods used.

The tables mentioned above all indicate GORE methods that are being used and available to use. The literature review provided a substantial amount of information for this research objective. The next part was to use this information to collect more information regarding this objective from the industry.

4.3.1.2 RESULTS FROM THE DATA ANALYSIS

The current state of GORE method use was measured by various questions. The demographic information provided in Section 4.2.2.3 indicated the profile of the companies and the individuals using GORE methods. The participants indicated that 88.10% are male, 64.29% are between the age of 22 and 30, 73.81% are developers, 30.95% have between 5 and 10 years of experience, and 42.86% have a university degree or equivalent. As for the companies, 42.56% were large, 66.66% operated on the internet or financial markets, 85.71% did systems development, and 33.33% of the projects' duration was less than 6 months.

Table 4-14 at Section 4.2.2.2 is the strongest indicator of current GORE method use. The results from this table indicated that 42 people used GORE methods and that 114 did not. The low number is however not a true indication of the entire population because the sample size was very small. In order to provide a more accurate description of the demographic information for GORE and traditional RE users, Table 4-15 and Table 4-16 provided individual demographic information as well as demographic information of the companies. These two tables presented the information both for GORE and traditional RE. The information also revealed that there is no statistically significant difference between these two groups in terms of the demographic information.

The information for the last project the participants worked on also provided an indication of the profile of the projects being developed using GORE methods. Table 4-19 provided this information and an interesting point is that all the projects that were developed using GORE had interaction with at least one other system. Table 4-20 provided in Section 4.2.2.4 indicates the GORE methods that were used in the projects. The participants indicated that GBRAM (55.00%), AGORA (35.90%), GOIG (37.50%), DOSS (41.02%), and NFR (50.00%) had been implemented to some extent and more while DTEBS (39.48%), VVA (47.37%), i* (55.56%), KAOS (39.47%) and TROPOS (52.63%) had been implemented to a lesser extent or not at all. Table 37 indicates the number of methods implemented during the project, with 51.72% of the projects having used between 1and 3 GORE methods.

4.3.1.3 CONCLUSION

This research objective was achieved by using both the literature review and the results from the questionnaire. The current state of GORE method use can thus be identified as follows: there are many GORE methods that are being used, as identified in the literature. The sample in this study indicated that only 42 out of 114 participants used GORE, which is a small number. This number, however, is not representative of the entire population as the literature indicated a much higher usage of GORE methods.

4.3.2 IDENTIFY CRITICAL ASPECTS THAT SHOULD BE ADDRESSED IN GORE METHODS

The second objective was to identify the critical aspects that should be addressed in GORE methods. This objective, again, was completed by reviewing the literature and by analysing data from questionnaires sent out to participants in the IT industry. The contribution of each of these will be discussed next.

4.3.2.1 LITERATURE REVIEW

The literature applicable to this objective is the same as for the previous objective. Table 2-9, Table 2-10, Table 2-11, and Table 2-12 all indicate aspects of GORE methods that should be addressed. The aspects evident in the literature will be discussed in this section.

The first aspect that is evident from all the tables mentioned is that there is no one GORE method that is suitable for every project. In addition to this, Table 2-9 provided by Aljahdali (2011:31) indicated that even the phases within the RE process all have different suitable GORE methods. Secondly, Table 2-12 provided by Horkoof and Yu (2011:680) indicated a trial-and -error approach to using GORE methods. This is a contribution to the previous aspect because it is also an indication that not one GORE method is suitable for all applications. The GORE process described in Section 2.2.3 indicates the important aspects that should be addressed for each phase and how they are carried out. Again, as there is no one perfect GORE method, the implementation of the RE process will be dependent on the GORE method and the GORE method can omit some of the aspects mentioned in Section 2.2.3.

The main critical aspect that was identified in the literature is that there is no one perfect GORE method. This can lead to the wrong method being implemented or point to a method that seems right but does not address the entire RE process. The information provided in the literature contributed to the questions in the questionnaire and the results in terms of this objective will be discussed next.

4.3.2.2 RESULTS FROM THE DATA ANALYSIS

The critical aspect mentioned above was not sufficient for the completion of this objective. The data analyses covered in Section 4.2 thus provide the following information in order to complete this objective:

The first critical component identified was the change in requirements. Table 4-32 in Section 4.2.3.2 identified factors regarding the change of requirements as follows: Problems regarding communication (78.80%), misunderstandings between stakeholders (59.53%), budget (59.53%) and scheduling (45.24%) concerns were all indicated as contributing to the changes in requirements. In addition, the participants indicated that the changes in requirements changed the budget (47.61%) as well as the schedule (73.81%) of the project. The second critical aspect identified is the level of strictness and intensity of the GORE methods. The success of the project and of the system was identified to be greater when the level of strictness and level of intensity were also high. In contradiction to this, the same test for traditional RE failed to identify any correlations. Thus, this level of strictness and intensity can be seen as a critical aspect.

The discussion of the two aspects above, although not an indication of the entire population, confirms that changes in requirements are still problems as mentioned in Chapter 1.

4.3.2.3 CONCLUSION

The discussion of the above two sections provided enough information to complete this objective. The critical aspects identified as the result of this objective, include the following: The selection of a GORE method that is right for the specific application is difficult as there are many to choose from. Changes in requirements as well as the level of intensity and strictness during implementation were also identified as critical aspects. The next section will discuss the critical aspects of requirement elicitation when using GORE.

4.3.3 KEY COMPONENTS AND SHORTCOMINGS OF REQUIREMENTS ELICITATION DURING GORE METHOD USE

The objective covered in this section was completed through both a literature review and the analyses of data collected from questionnaires sent out to participants in the IT industry. This section will also discuss how this objective was completed in terms of the literature review and the data analysis.

4.3.3.1 LITERATURE REVIEW

The objective for this section, to identify key components and shortcomings of requirements elicitation during GORE method use, was easier to complete in terms of the literature review. Requirements elicitation is a phase evident in both traditional RE and GORE and, although this objective is related to GORE method use, literature from Section 2.1 and Section 2.2 was used to identify the key components.

The first component identified was the selection and use of the elicitation techniques. Section 2.1.4.1.1 provided Table 2-2, which described a list of techniques that can be used. The key component here is to identify the correct technique for the project and, as discussed in section 4.3.2.1 for the GORE methods, selecting the right one is also difficult. The second componentis the elicitation of the right goals. Section 2.2.3.1 described the influences of this selection, thus indicating that it is a difficult process. The third aspect identified is that, because this process is iterative (see Section 2.2.3), this phase must make provision for the identification of new goals throughout the development process. An important component, also identified by data analysis, that influences the previous three aspects is communication. Hickey and Davis (2003:4) illustrated the communication channels in Figure 2-6, and this was an indication of the complexity of this component.

The literature review provided a substantial amount of information that helped to identify the aspects for this objective. The information gathered was also used to formulate the questionnaire which was created to collect more data in order to complete this objective. The results from the data analysis will be discussed next.

4.3.3.2 RESULTS FROM THE DATA ANALYSIS

Requirements elicitation within GORE is the main focal point of this study. The literature provided sufficient information but in order to complete this objective, an analysis of data from questionnaires sent out to participants in the IT industry was also needed. The questionnaire included an entire section dedicated to this objective. The results from the analysis will be discussed next.

The first components identified were reported in Table 4-36 in Section 4.2.4.1.2. The discussion there explained that some techniques required extra knowledge, were time-consuming, and required extra resources. The techniques implemented were also insufficient for identifying all the requirements for 19.88% of the participants. Two factors that were identified and seen as critical components were indicated at Section 4.2.4.1.3 and contributed to the communication issue The first was the need for communication and the second indicated that there is difficulty in communicating the requirements. The final component relating to this objective was the selection of an elicitation technique. Table 4-45 indicated the influence of the selected technique on the success of the project and the success of the system. Section 4.2.4.2.2 discussed that the use of certain techniques resulted in higher success both for the system and the project. The use of task analysis, domain analysis, and the analysis of existing documents, manuals and existing systems all indicated a correlation with a medium effect size, thus the implementation of these methods indicated better success of the project. The use of surveys, questionnaires, JAD, and the analysis of existing documents, manuals and existing systems, task analysis and domain analysis indicated that the implementation of these methods resulted in better success of the system.

The results from the data analysis contributed to this objective because they identified components critical to the requirements elicitation process and GORE method use. Certain techniques caused certain problems such as requiring extra knowledge to implement, requiring to change during the development, were time-consuming, required extra resources, and were not sufficient in identifying all the requirements. Some techniques may lead to better success in the system and project (as mentioned in the previous paragraph). Communication was also identified as a critical factor.

4.3.3.3 CONCLUSION

This section discussed how the research objective was completed in the study. The objective was completed and the following identified: The literature indicated that there are many techniques but that certain techniques are only suitable for certain problems. This indicated a problem with the selection of elicitation techniques and this was confirmed through the data analysis: some techniques showed a higher influence than others on the success of the project and system. The requirements elicitation techniques were also shown to be insufficient in identifying all the requirements. Communication was identified both through literature and the data analysis and produced two facts: that there is a need for communication and that communication during this phase is difficult.

4.3.4 FRAMEWORK TO ADDRESS THE PROBLEMS

The final objective and the purpose of the study are to create a framework that can be used to resolve the problems identified in the previous two objectives. The proposed framework is provided and discussed in Chapter 5. The creation of the framework also indicates that this research objective has been completed.

4.4 CONCLUSION

Chapter 4 provided the results from the data analysis on the data collected from questionnaires that were sent out to participants in the IT industry. The results and discussion of the reported results were provided at Section 4.2. All the results that contributed to the aims and objectives of the study were reported accordingly. Section 4.3 provided an evaluation of the results and how they contributed to completion of each of the research objectives. Together with this evaluation, the contribution and reference to the literature review provided in Chapter 2 were also discussed for each of the objectives. The final part of this study is to present the proposed framework as discussed in Chapter 1. The framework, together with its discussion, is provided in Chapter 5.

CHAPTER 5 – PROPOSED FRAMEWORK

5.1 INTRODUCTION

This chapter will present the proposed framework. The results reported in Section 4.2 together with the information collected during the literature review in Chapter 2, were used to create the framework. The proposed framework will focus on the following:

- The proposed framework will focus only on the requirements elicitation phase, and will thus not constitute a complete new GORE method. The results allowed for the identification of components to be addressed but were not sufficient to make inferences about the entire population for creating a new GORE method. The framework proposed was thus developed to be used in conjunction of GORE methods and assist in the elicitation of requirements.

The framework will be presented in two sections. The first section will indicate and discuss the applicable area of the framework and its place in GORE. The second section will provide the proposed framework with the discussion.

5.2 THE PLACE OF THE FRAMEWORK IN GORE

The literature review of GORE in Chapter 2.2 discussed the GORE process, with the relevant phases. The main purpose of the framework is to improve the requirements elicitation process, but as indicated in Section 2.2.3 and illustrated by Vinay *et al*., 2011:2, all of the other phases of the GORE process is related in some way to the elicitation process. To provide a better understanding of where this framework will be used, the following illustration is provided:

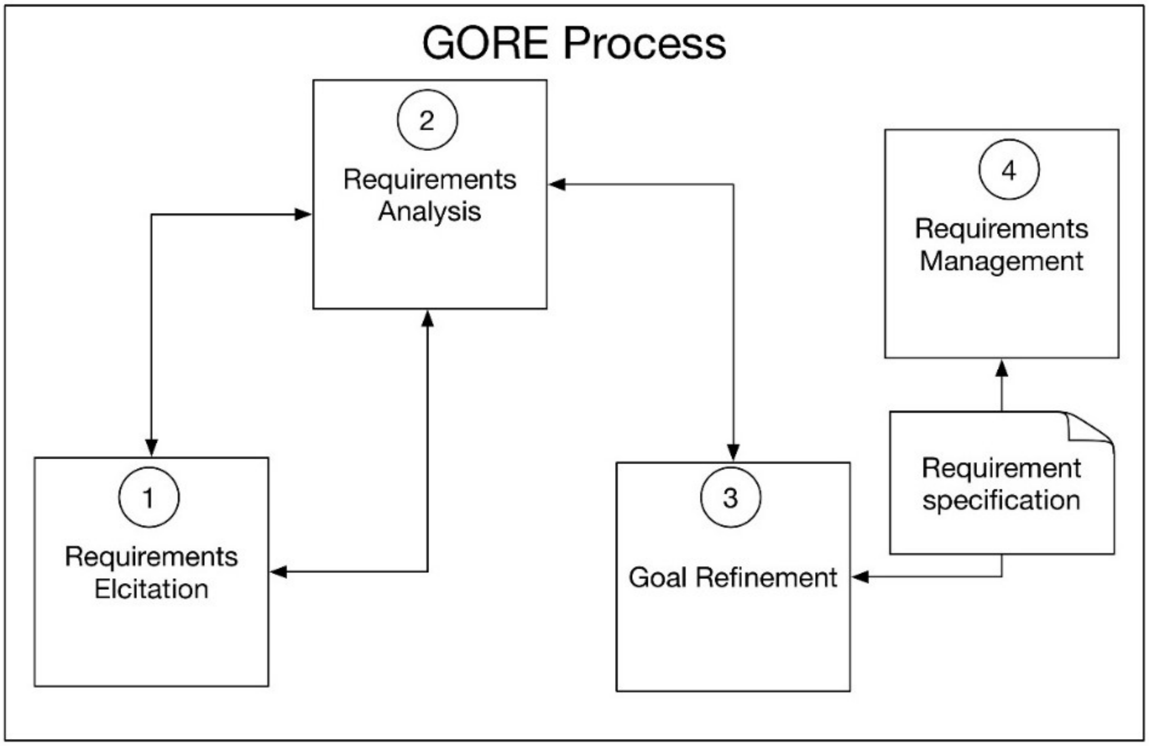

Figure 5-1: **Simplified GORE process**

Figure 5-1 provides a simple illustration of the GORE process. This illustration was created with the information gathered from the literature review on GORE in Section 2.2 (Vinay *et al*., 2011:2; Aljahdali *et al*., 2011:331).

- The first step in the illustration is the requirements elicitation phase, labelled accordingly. Bi-directional arrows are connecting this process with the second step, the requirements analysis phase.
- The requirements analysis phase is connected to the goal refinement phase and that in turn is connected to the requirements management. The box between goal refinement (3) and goal management (4) indicates the requirements specification document, which is the main output of phases 1-3, as described in Section 2.2.3.3.
- Outputs from phases 2-4 can all result in the activation of another iteration of the elicitation process.

Figure 5-1 serves two purposes, the first to illustrate the GORE process from phase 1 to 4, and the second to illustrate the repetitiveness of this process, indicated by the bidirectional arrows.

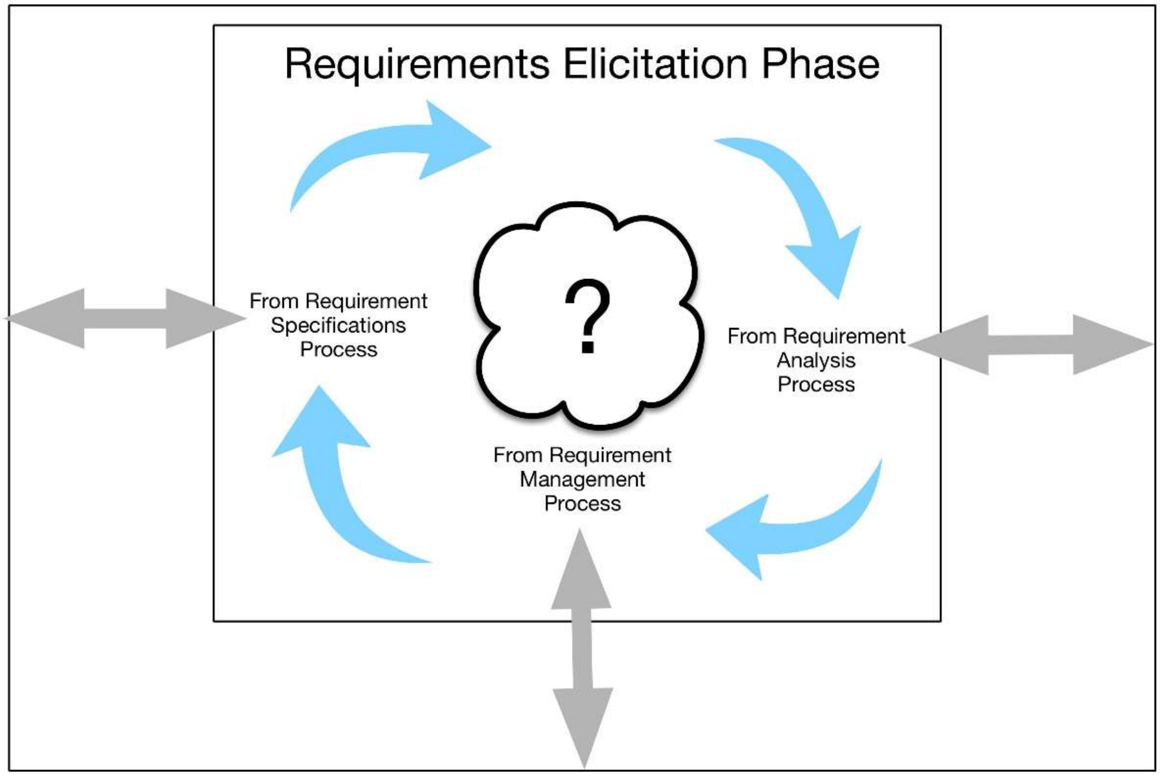

Figure 5-2: Requirements Elicitation phase and connections

Figure 5-2 represents the requirements elicitation phase within the GORE process. The bi-directional arrows on the left and the right indicate the interaction with the other phases in the GORE process. The blue arrows, depicting a loop, indicate the iterative property of this phase. Finaly, the bubble in the middleindicates where the framework will be used. Thus, from Figure 5-1 and Figure 5-2, the following two points can be derived:

- The proposed framework is independent of the GORE method and works within the elicitation phase.
- The framework needs to accommodate iteration as well as input and output from and to the other phases.

The two figures, Figure 5-1 and Figure 5-2, illustrate where the framework will operate but also some properties that must be considered. The purpose of this section of the chapter was to provide a short background and illustration of the framework. The next section, Section 5.3, will provide the full proposed framework.

5.3 PROPOSED FRAMEWORK

5.3.1 INTRODUCTION

This section will provide the proposed framework, as introduced in the previous section. The purpose of this chapter is to provide the proposed framework and indicate its contribution to the research objective. The proposed framework will address the components identified in the other objectives mentioned at Section 4.3.

5.3.2 THE FRAMEWORK

The proposed framework, the result of the data analysis at Section 4.2 and of the literature review, is illustrated in Figure 5-3. The framework was developed in terms of areas of importance, identified in Section 4.3. The main components are thus:

- Problem domain;
- The elicitation techniques (Section 4.3.3);
- Communication (Section 4.3.3 and Section 4.3.2);
- Requirements changes (Section 4.3.2); and
- Interaction with the other phases (Section 4.3.2 and Section 2.2.3).

These components were selected as a result of the data analysis in Section 4.2 and the discussion of the objectives in Section 4.3. The discussion of these components will be discussed after the presentation of the proposed framework.

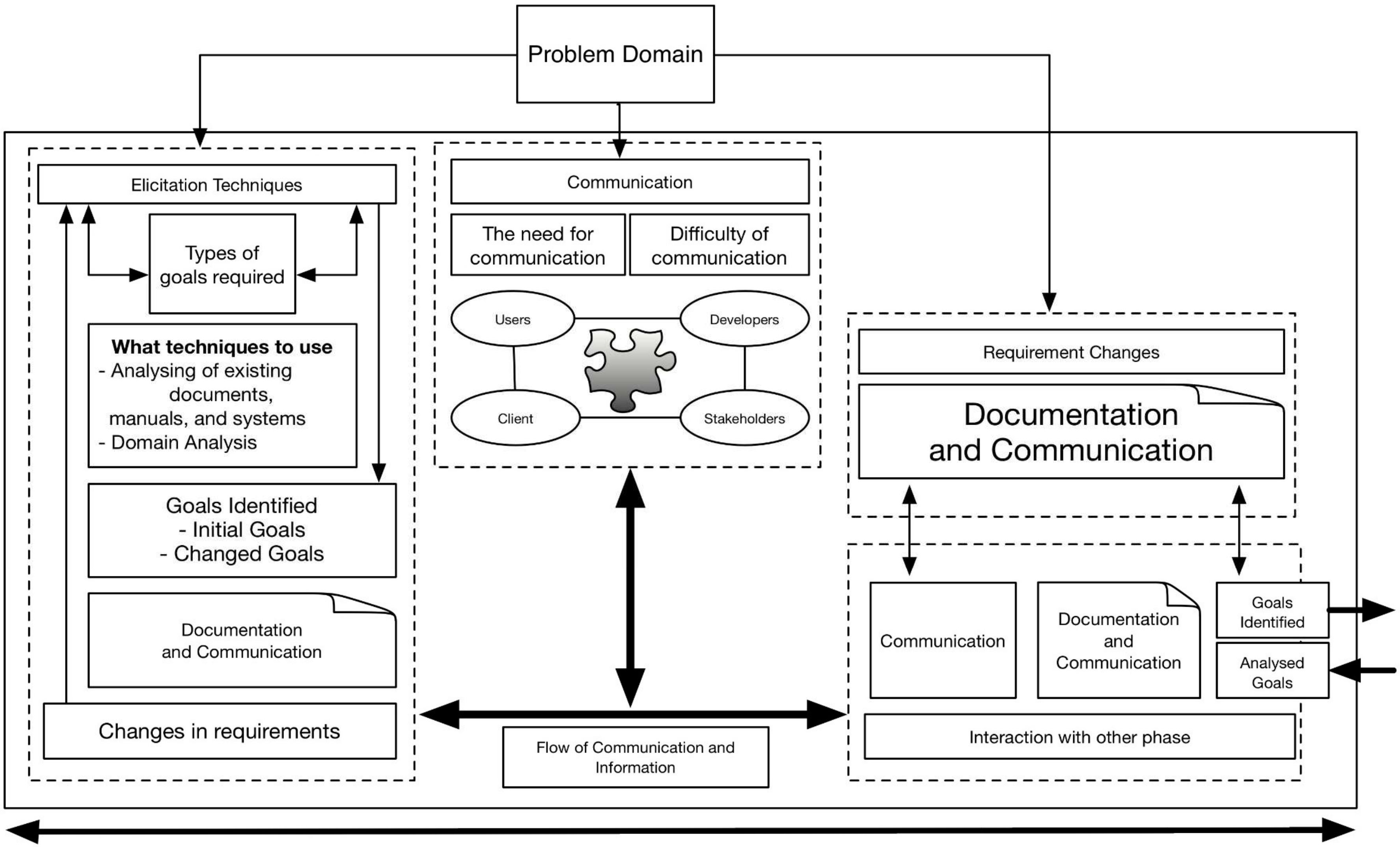

Figure 5-3: **Proposed framework**

5.3.2.1 THE PROBLEM DOMAIN

The problem domain is the first component evident in the framework. The reason for RE, as described in Section 2.1.1, is to describe the system being developed. The problem domain illustrated in the framework refers to the system being developed or a problem that needs a solution. The problem domain thus provides the reason for the development of a new product/system. The problem domain, as illustrated, influences all of the other components.

- Requirements elicitation: The problem domain defines the problem that needs a solution and thus will influence the selection of the elicitation techniques, the selection and identification of goals, and determine the stakeholders involved.
- Changes in the requirements: Changes in the problem domain can result in changes in the requirements. Changes in requirements are inevitable, as identified in Section 2.1.4.1. These are almost impossible to prevent and so it is important to analyse the problem domain carefully in order to minimise changes.
- Communication: Communication is a prominent component in the framework and is applicable to all the different parts of the framework. The problem domain will determine *who* will be communicating *what information*. The communication component will be discussed in Section 5.3.2.3.

5.3.2.2 THE REQUIREMENTS ELICITATION

The purpose of the framework is to improve the requirements elicitation phase when implementing GORE. The requirements elicitation component consists mainly of the following sub-components:

- The elicitation techniques used will depend on different variables, which include the problem domain as well as other uncontrollable variables. Thus, two of the most successful techniques identified in the study are proposed as starting point (see Section 4.3 and Section 2.1.4.1). The identification of goals is closely related to the techniques used because the type of goals needed will influence the type of technique and vice versa. The purpose here is not to provide a specific technique to use for all projects, but to indicate the influence of the problem domain on the selection of the technique.
- The changes in requirements indicate the adaptability of the framework. The sources of changes in requirements, as illustrated in Figure 5-3, are evident in various sections of the framework and outside the framework. The arrow from the changes in requirements to the elicitation technique indicates that the elicitation technique may change, depending on the change of requirements. GORE identifies goals, which are analysed to identify the requirements. Identification of new requirements can also lead to changes.

- Documentation and communication: This component is also evident throughout the framework and its inclusion emphasises its importance. Section 4.2 indicated the need and difficulty of communication and thus communication is needed throughout the framework. Communicating the correct elicited goals as well as what is needed is a critical aspect of the requirements elicitation phase. This will be explained more fully in Section 5.3.2.3.
- Identified and changed goals: This illustrates that the changes in goals and identification of new goals are seen as outputs of the elicitation techniques.

5.3.2.3 THE COMMUNICATION

The next component is communication. This was identified as a critical component in Section 4.2 and Section 4.3. Communication is illustrated in the centre of the framework (see Figure 5-3) and is connected to all the other components. Within the communication component the following elements are addressed.

- The need for communication and the difficulty of communication: The results in Section 4.2 indicated that the need for communication and the difficulty of communication are important factors in the requirements elicitation process. The need for communication, indicated in the top middle of Figure 5-3, resulted in the use of the documentation and communication component in Figure 5-3. The documentation and communication component indicate that communication must occur throughout the elicitation process. The difficulty is also addressed by the documentation and communication component. In addition to illustrating the need of communication, it also illustrates how the communication flows between components and the different levels. The documentation indicates the main method of communication. Communication should be acceptable and understandable at all the levels. Again, the framework illustrates only the importance of this given that finding a solution to all the mentioned problems falls outside the bounds of the study.
- The second part indicates the common stakeholders involved. The picture of the puzzle piece, illustrated in the middle of the communication component at the middle-top of Figure 5-3, indicates that communication between these stakeholders are key in the elicitation process. Each of the stakeholders will influence the elicitation of goals and thus communication is key between them. Communication between different levels, as mentioned in the previous point, plays a major role here. Communication between these stakeholders must occur on all levels so that there is a great degree of understanding. Results from Section 4.2 indicated that miscommunication and misunderstanding between stakeholders contribute to incompleteness of the requirements elicitation.

- Communication will also influence the type of elicitation technique that will be used. If the stakeholders do not prefer the method of communication entailed in the elicitation technique, another technique may be used.

The communication part of Figure 5-3 illustrates (1) the importance of communication, (2) components related to the communication part, and (3) the interaction between stakeholders on different levels which influences the elicitation of requirements.

5.3.2.4 CHANGES IN REQUIREMENTS AND INTERACTION WITH OTHER PHASES

Changes in requirements are inevitable and thus the framework does not supply a simple remedy to prevent changes from taking place. The framework does, however, indicate the important factors that should be considered important during requirements elicitation. Accompanying the changes of requirements is the interaction with other systems. Most of the changes in requirements have resulted from another phase within GORE. The framework indicates how changes should be documented and communicated (as described in the previous section) and how these changes are received by the framework.

- The goals that are identified using the elicitation techniques are analysed in the analysis phase of GORE, thus the arrow at the bottom right of Figure 5-3 points to the outside of the framework. The analysed goals are then received back and used for further elicitation.
- The communication and documentation part of the change in requirement component focuses on the different levels and systems. Each of the phases can produce outputs and thus communication needs to occur before outputs are sent and inputs are received, to ensure the correct transition of information.

The interaction of requirements elicitation with other phases is not limited to the analysis phases, the other phases identified in Section 2.2.3 can also interact with this phase. This contributes further to the importance of communication.

5.3.3 CONCLUSION OF THE PROPOSED FRAMEWORK

The proposed framework provided in Section 5.3.2 and discussed in the subsequent section illustrates the output of this study. The research objectives stated in Chapter 1 were reached and the information gathered was used to create the framework. The framework is not a GORE method on its own but a framework that can be used for the elicitation phase of a GORE method. The framework provides guidelines and points of importance, rather than indicating specific techniques to use during requirements elicitation. The framework does, however, complete the final research objective as mentioned in Section 4.3.4.

5.4 CONCLUSION

This chapter provided the proposed framework as part of the research aims and objectives described in Chapter 1. The results from the statistical analysis and the literature review was a critical component in the process of creating the framework. The creation of the framework was the last objective of the study. The conclusion of the study will be provided in Chapter 6.

CHAPTER 6 – CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

This chapter will conclude the study and discuss the limitations of the research as well making recommendations for future research. It will provide a review of the purpose of the study, followed by a summary of the results. The limitations of the study together with recommendations for future studies will then be discussed. The final section will conclude the study.

6.2 REVIEW OF THE RESEARCH OBJECTIVES

The aim of the research was to develop a theoretical framework in GORE with the focus on requirements elicitation. In order to develop this framework, the following objectives had to be completed:

1. Identify the current state of the GORE method use;
2. Identify critical aspects that should be addressed in GORE methods;
3. Identify key components and the shortcomings of the requirements elicitation process followed in various GORE methods;
4. Develop a framework that will address the problems identified in objectives 1 and 2; and
5. Make recommendations based on the findings for future research.

6.3 SUMMARY OF THE RESULTS

The results provided in Section 4.2 were used to complete the objectives mentioned in the previous section. The results were provided according to the conceptual model that was created in Chapter 3. Following, is a summary of the results.

6.3.1 SUMMARY OF STATISTICAL ANALYSIS

Data was collected from 156 participants. The first part of the analysis provided the demographic information of the sample. The demographic information for the participants as well as the demographic information of the companies was provided. Data regarding the last project the participants worked on was analysed next in order to identify the current state of GORE method use. The results indicated a problem with the distinction between GORE users and traditional RE users, and further analysis revealed that GORE was represented by 42 participants and traditional RE was represented by 114 participants. Group 1 was used as the GORE group and Group 2 was the traditional RE group. These two groups were used as a focus component throughout the rest of the analysis process.

The division of the two groups allowed the researcher to determine if there was any difference between the participants using GORE and traditional RE in the demographic information mentioned above. No statistical difference was found in any of the demographic information. The next part of the analysis of the project information, and contribution of the results to the research objective, was to identify the use of GORE methods. GBRAM was implemented 55.00% of the time to some extent and more, while i*indicated the lowest implementation extent, with 50% indication of no implementation. The success of the project and the success of the system were then identified as two factors, which were used in subsequent analyses.

The results of the questions related to the RE process was then reported. It was identified that the requirements elicitation phase had been the most difficult, at 19.05%, while 45.23% indicated that it had been easy. Problems regarding communication (78.80%), misunderstandings between stakeholders (59.53%), budget (59.53%) and scheduling (45.24%) concerns were all indicated as contributing to the changes in requirements. In addition to these, changes in the requirements were indicated to change the budget (47.61%) as well as the schedule (73.81%) of the project. Finally, 50% of the participants indicated that using the GORE method improved the ability to manage changes in requirements. The management of changes in requirements was identified as being easier when using GORE than when using traditional RE.

The final focal point was the implementation of GORE and RE. The analysis of the elicitation process showed that 19.88% of the participants indicated that the techniques were not sufficient in identifying all the requirements, while 42.31% indicated that the techniques were sufficient. The result of the factor analysis on the questions related to communication revealed two factors, one regarding the need for communication and the other regarding the difficulty of communication. The correlation between (1) the chosen elicitation technique and (2) the success of the system and project for Group 1 indicated the following. The use of task analysis, domain analysis, and the analysis of existing documents, manuals and existing systems all indicated a correlation with a medium effect size that is statistically significant regarding the success of the project. Thus, the implementation of these methods indicated better success of the project. The use of surveys, questionnaires, JAD, and the analysis of existing documents, manuals and existing systems all indicated a correlation with a medium effect size that is statistically significant regarding the success of the system. Task analysis and domain analysis indicated a correlation with a high effect size that is statistically significant regarding the success of the system Thus, the implementation of these methods resulted in better success of the system.

Another correlation was tested between the level of intensity and strictness, and the success of the project and system. It was found that a correlation existed between the level of intensity and strictness, and the success of the project and system with a high effect size that was statistically significant. The sample indicated improved success both for the project and the system when the GORE method was implemented more intensively. There was a correlation with a high effect size that was statistically significant. The sample indicated improved success both for the project and the system when the GORE method was implemented more rigorously

6.3.2 COMPLETING THE RESEARCH OBJECTIVES

The research objectives were all completed. This section will provide a brief summary of the completed objectives.

- **The current state of GORE method use:** This research objective was achieved by using both the literature review and the results from the questionnaire. The current state of GORE method use can thus be identified as follows: There are many GORE methods that are being used, as identified in the literature. The sample indicated that only 42 out of 114 participants used GORE, which is a small number. This number, however, is not representative of the IT population given that the literature indicated a much higher use of GORE methods
- **The critical aspects that should be addressed in GORE methods:** The critical aspects identified as the result of this objective include the following. The selection of a GORE method that is right for the specific application is difficult as there are many to choose from. Changes in requirements as well as the level of intensity and strictness during implementation were also identified as critical aspects. The next section will discuss the critical aspects of requirements elicitation when using GORE.
- **Key components and shortcomings of requirements elicitation in GORE methods:** The literature indicated that there are many available techniques but that certain techniques are only suitable for certain problems. This indicated a problem with the selection of elicitation techniques and the data analysis confirmed this because some techniques showed a higher influence on the success of the project and system. The requirements elicitation techniques were also indicated as being insufficient in identifying all the requirements. Communication was identified both in the literature, and the data analysis and produced two factors, there is a need for communication and communication during this phase is difficult.

- **Proposed framework:** The proposed framework provided in Section 5.3.2 and discussed in the subsequent section, illustrated the output of this study. The research objectives stated in Chapter 1 were completed and the information gathered was used to create the framework. The framework is not a GORE method on its own but a framework that can be used for the elicitation phase of a GORE method. The framework provides guidelines and points of importance, rather than indicating specific techniques to use during requirements elicitation.
- **Providing recommendations:** The results of the study revealed recommendations for future research. These recommendations are discussed in Section 6.4.

6.4 LIMITATIONS, RECOMMENDATIONS AND CONTRIBUTION

The research objectives of this study were achieved although various limitations were identified during the research process. The proposed framework also allowed for recommendations for future research. This section will discuss these two aspects.

The first limitation that was evident was the response to the questionnaires. Although sufficient responses were collected in order to preform statistical data analysis, the data indicated that the sample was not a clear representation of the IT population. Furthermore, the number of participants who used GORE was also low, which limited the data analysis and results. The questionnaire itself also indicated limitations. The collection of responses was also limited due to time constraints. The framework did address the problems in the research objectives but the impact of the framework in the industry is unknown. The framework has also not been tested in the industry, which adds to the previous statement.

Recommendations from the study include the following:

- The first recommendation is related to the sample of the study. The study could be done again with a larger sample size. This can provide a better indication of GORE method use in the industry.
- The second recommendation is related to the type of research. Quantitative research was conducted and thus the use of qualitative research on this subject can provide additional results.
- The third recommendation is related to the framework. The proposed framework isn't tested within the industry. Testing the framework can provide information regarding the effectiveness and usefulness of the framework.

- The fourth recommendation is also related to the framework. The critical components of the framework can each be studied individually to refine the framework or identify additional components.
- The final recommendation is related to GORE method use. There is still room for further research regarding the different phases of RE within GORE, especially the requirements elicitation phase. The research conducted should be of the different phases of RE within GORE, independent of specific GORE methods. This can provide results that can be implemented within GORE regardless of a specific GORE method.

The above recommendations complete the final research objective which is to provide recommendations. The study identified these recommendations that can be implemented in future research.

The final point of discussion is the contribution of the study for both the industry and academia.

- **The industry**: The contribution to the industry is a framework that can be used as a guide for the implementation of the requirements elicitation phase when a GORE method is used. Furthermore, the framework is independent of the GORE method and can be implemented in a wider area of the industry.
- **Academic**: The academic contribution of the study is also a framework. The framework provides components that can be used in future studies regarding GORE. In addition, testing the framework can further identify aspects that can be used in future studies. Thus, in addition to being a framework that can be implemented, it also contains subjects of future research regarding GORE.

6.5 FINAL CONCLUSION

This study was undertaken with the main objective of creating a framework that could be used to improve the requirements elicitation process when using GORE. A literature review was conducted and identified the opportunity for the study, thus providing the impetus for the investigation. The first step was to identify the research methodology followed during the study. A positivist research paradigm was used with surveys as research strategy. Questionnaires were used as a data collection method and the questions were identified with the use of a conceptual model. Statistical analysis was used to analyse the data and to produce results.

The results, together with the literature review, was used to meet the research aims and objectives. The final objective was to create a framework, which was provided and discussed.

The study is considered a success, although there is still much research that can be done not only regarding the proposed framework but also more widely in GORE.

CHAPTER 7 – REFERENCES

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ANNEXURE A – COVER LETTER

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June 2015

Best IT Professional

RESEARCH ON THE USE OF GOAL ORIENTED REQUIREMENTS ENGINEERING METHODS EN REQUIREMENTS ELICITATION

The ever changing environment of information technology results in changes in requirements throughout the development life cycle. The need to adapt to these changes resulted in agile systems development methodologies. Together with this more adaptive systems development method, Goal Oriented Requirements Engineering (GORE) was introduced.

This technique relies on goals being established and that requirements are extracted from these goals. Agents (stakeholders/ systems/ etc.) are responsible to reach these goals and can influence one another. GORE also developed at a rapid rate and resulted in various models which include KAOS, GBRAM, AGORA, NFR, and i* (i-Star). Each of these were introduced in order to cater for some shortcoming in GORE. It is evident from these models (and traditional RE) that requirements elicitation is still a hurdle in RE

In order to identify the specific shortcomings in terms of requirements elicitation in GORE, we need information from individuals active in the field. Would you please help us and complete the following questionnaire? It would take approximately 30 minutes of your time. All the information will be treated confidentially, and if you are interested, we will send you a copy of our findings.
We really need your help!

I would appreciate it if the questionnaire could be completed as soon as possible.

Yours sincerely

Mr Matthys Geyser
Masters Student

E-mail: 22115080@student.nwu.ac.za

ANNEXURE B – QUESTIONNAIRE

Section A – Personal Information

A.1 Gender	
Please indicate your gender :	
1. Male 2. Female	

A.2 Age	
Please indicate your age :	
1. 18 or less 2. 19 – 21 3. 22 – 30 4. 31 – 40 5. 41 – 50 6. 51 – 60 7. 61 or older	

A.3 Current position	
Please indicate your current position :	
1. Chief Information Officer 2. Information Systems Manager 3. Project manager 4. Developer 5. System analyst 6. Other – Please specify ______________________________	

A.4 Years of experience

Please indicate the number of years of experience in systems development :	
1. Less than 1 year 2. 1 year or more – less than 2 years 3. 2 years or more – less than 5 years 4. 5 years or more – less than 10 years 5. 10 years or more	

A.6 Personal qualification	
Please list the highest qualification obtained :	
1. Senior Certificate (High School) 2. Certificate or Diploma 3. University degree or equivalent degree 4. Honours degree 5. Masters' degree 6. Doctoral degree 7. Other ____________________________________	

Section B – Company Information

B.1 Size of company	
Please indicate the size of the company (in terms of employees) :	
1. Small (Up to 50 employees) 2. Medium (Between 50 and 200 employees) 3. Large (More than 200 employees)	

B.2 Market

Please indicate the most common market the company operates in (at most two):	
1. Retail market 2. Media markets (such as broadcast, television, etc.) 3. Internet markets (such as electronic commerce, etc.) 4. Financial markets 5. Other ____	

B.3 Type of development	
Please indicate the most common type of the development the company does (at most three) :	
1. Application Development (Non-web based software) 2. Systems Development 3. Web Development 4. Embedded Systems Development (Software working on non-computer devices) 5. Test Automation (Software that tests other software) 6. Other ____	

Section C – Project Information

Please answer the following questions based on the last systems development/ information technology project you worked on.

C.1 Size of the project	
Please indicate the size of the project.	
1. Small 2. Medium 3. Large	

C.2 Nature of the project	
Please indicate the nature of the project.	
1. New development project 2. Upgrading a previous project 3. Redeveloping a previous project	

C.3 Development time of the project	
Please indicate the development time of the project.	
1. Less than 6 months 2. 6 months or more – less than 1 year 3. 1 year or more – less than 2 years 4. 3 years or more – less than 4 years 5. 4 years or more – less than 5 years 6. 5 years or more	

C.4 Type of project	
Please give a brief description of the project	
____	

C.5 Interaction with other systems	
Please indicate the number of other systems the project interact with.	
1. None 2. 1 – 2 systems 3. 3 – 4 systems 4. More than 5 systems	

C.6 Use of a Systems Development Methodology (SDM)					
Where there an SDM used during the development of the project? :					
1. Yes 2. No					
If you indicated yes, to what extent was the following SDMs used?					
	Not at all	To a little extent	Neutral	To some extent	To a greater extent
Systems Development Life Cycle (SDLC)					
Object Oriented Analysis and Design (OOAD)					
Information Engineering (IE)					
SCRUM					
Extreme Programming (XP)					
Rapid Application Development (RAD)					
Unified Modelling Language (UML)					
Other ______________________________ __					

C.6.1 If you indicated yes at answer C.6, please answer the following question.	
Why was the SDMs chosen?	
____	

C.7 Use of Traditional Requirements Engineering	
Was traditional RE used during the development of the project? :	
1. Yes 2. No	

C.7.1 If you indicated yes at answer C.7, please answer the following question	
Why was traditional RE used during the development of the project? :	
____	

C.8 Use of a Goal Oriented Requirements Engineering (GORE)	
Were there a GORE method used during the development of the project? :	
1. Yes 2. No	
If you indicated yes, to what extent was the following GORE methods used?	

	Not at all	To a little extent	Neutral	To some extent	To a greater extent
Goal-Based Requirements Analysis (GBRAM)					
Attribute goal-oriented requirements (AGORA)					
Deriving tabular event-based specifications (DTEBS)					
Visual Variability Analysis (VVA)					
Goal-Oriented Idea Generation Method (GOIG)					

Deriving Operational Software Specifications (DOSS)					
Non-functional Requirements (NFR)					
I* (i Star)					
Knowledge Acquisition in automated Specification (KAOS)					
TROPOS					
Other ______________________________ __					

C.8.1 If you indicated yes at answer C.8, please answer the following question.	
Why was the GORE method chosen?	
____	

C.9 Success of Project					
To what extent do you agree with the following statements regarding the success of the project?					
	Totally Disagree	Mostly Disagree	Neutral	Mostly Agree	Totally Agree
The project was completed on time					
The project was completed within the budget					

The project satisfied all the requirements					
The development speed was fast					
The project achieved its goals					
Overall, the project was a success					

C.10 Success of delivered system					
To what extent do you agree with the following statements regarding the success of the delivered systems?					
	Totally Disagree	Mostly Disagree	Neutral	Mostly Agree	Totally Agree
The functionality of the developed system is high					
The reliability of the developed system is high					
The maintainability of the developed system is high					
The portability of the developed system is high					
The efficiency of the developed system is high					
The usability of the developed system is high					
The developed system meets user needs					
The documentation of the developed system is good					
Overall the quality of the developed system is high					
Overall, the users are satisfied with the developed system					

Overall, the developed system is a success					

Section D – Requirements Engineering

Please answer the following questions based on the last systems development/ information technology project you worked on.

D.1 To what extent do you agree with the following statements regarding the Requirements Engineering (RE) of the project?					
	Totally Disagree	Mostly Disagree	Neutral	Mostly Agree	Totally Agree
	1				5
The RE process It was easy to complete the following phases 1. Requirements Elicitation 2. Requirements Analysis 3. Requirements Specification 4. Requirements Validation					
Changes in the requirements 1. Changes in requirements were due to: 1.1. Communication problems 1.2. Misunderstanding between stakeholders 1.3. Reasons concerning the budget 1.4. Reasons concerning the schedule 1.5. Reasons concerning the development team 1.6. Implementing the wrong elicitation technique 2. The changes in the requirements changed the budget of the project					

3. The changes in the requirements changed the schedule of the project 4. There was a low number of changes in the requirements throughout the development 5. The RE method made it easy to manage the changes in the requirements					

D.2 To what extent do you agree with the following statements regarding the Requirements Elicitation of the project?					
	Totally Disagree	Mostly Disagree	Neutral	Mostly Agree	Totally Agree
Requirements Elicitation tasks It was easy to complete the following tasks 1. Create an initial scope document 2. Identification of the actual requirements 3. Prioritise and determine releases 4. Review and inspect artefacts					
Implementation of elicitation techniques 1. The selected elicitation techniques is straight forward and easy to implement 2. No extra knowledge or extra training is required to implement the selected techniques 3. The selected elicitation techniques changed during the development process 4. The selected techniques were time consuming 5. The selected techniques required extra resources 6. The selected techniques required changes in the budget 7. The selected techniques were sufficient to identify all the necessary requirements					

Communication during the requirements elicitation 1. There was a need for frequent communication 2. There was a need for communication between different organisational levels 3. The degree of communication influences the chosen requirements elicitation techniques 4. Communication between the different stakeholders were difficult during the requirements elicitation phase 5. Problems with communication resulted in incomplete or faulty requirements 6. Overall, communicating requirements is difficult.					

D3 Requirements Elicitation techniques					
To what extent was the following RE elicitation techniques are used?					
	Not at all	To a little extent	Neutral	To some extent	To a greater extent
Interviews					
Surveys					
Questionnaires					
Task Analysis					
Domain Analysis					
Analysis of existing documents, manuals and existing systems					

Card sorting					
Protocol Analysis					
Group work					
Brainstorming					
Joint Application Development (JAD)					
Requirements workshops					
Prototyping					
Use cases					
Scenarios					
Ethnography					
Observations					

Section E – Goal Oriented Requirements Engineering (GORE) usage

Please answer the following question regarding GORE method use based on the last project. Answers these questions if the **answer** to **C8** was **Yes.**

E.1 Number of GORE methods	
How many GORE methods do you use?	
____	

E.2 Usage of the GORE methods	
On a scale of 1 to 10:	

1. How intense is the GORE methods implemented? 2. How strictly do you regard the use of the GORE methods during development?	

To what extent do you agree with the following statements regarding the GORE method use?

	Totally Disagree	Mostly Disagre	Neutral	Mostly Agree	Totally Agree
The use of GORE methods improve the identification of requirements					
GORE methods help to understand the stakeholders better					
GORE methods improve the management of requirements					
Communication are improved due to the use of GORE methods					
GORE methods improve the following phases of RE 1. Requirements Elicitation 2. Requirements Analysis 3. Requirements Specification 4. Requirements Validation					
GORE methods improve the ability to keep by the: 1. The budget of projects 2. The schedule of projects 3. The goal of projects					
Overall, the use of GORE method improves the quality of requirements					
Overall, the use of GORE method improves the communication during the RE process					

Overall, the use of GORE method improves the RE process					
Overall, the use of GORE method impacts outcome of the project					

Section F – Traditional Requirements Engineering (RE) usage

Please answer the following question regarding Traditional RE method use. Answers these questions if the **answer** to **C7** was **Yes**

F.1 Usage of Traditional RE.	
Which of the following statements describes the RE situation the best? 1. The organisation has never considered the usage of GORE methods 2. The organisation has considered the usage of GORE methods, but decided against it 3. GORE methods was previously used but the organisation abandoned it **On a scale of 1 to 10:** 4. How intense is traditional RE implemented? 5. How strictly do you regard the use traditional RE during development?	

F.2 To what extent do you agree with the following statements regarding traditional RE and not the usage of GORE methods

	Totally Disagree	Mostly Disagre	Neutral	Mostly Agree	Totally Agree
	1				5
GORE methods are unknown					
GORE methods are too difficult to implement					
Implementing GORE methods will require extra training which doesn't justify its usage					
Overall, the use of traditional RE is sufficient for development					
The development team doesn't have the required knowledge to implement GORE method use					
The use of GORE methods is not suited for the development environment					
Top management prevents/prohibits the use or change to GORE/other methods					
The benefits of the use of GORE methods is uncertain					
Traditional RE is sufficient for the following phases: 1. Requirements Elicitation 2. Requirements Analysis 3. Requirements Specification 4. Requirements Validation					
Traditional RE is sufficient for: 1. Communicating requirements and resolving communication conflict 2. Identifying all the necessary requirements 3. Keeping requirements consistent with plans and work products					

4. Establishing and maintaining an agreement with the customer and users of the requirements 5. Manage and track changes in the requirements 6. Identifying new, evolving requirements					

Thank you for your kind participation ☺