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THE ROLE OF KNOWLEDGE CAPTURING DURING THE ELICITATION OF SYSTEM REQUIREMENTS IN A HIGH RELIABILITY ORGANISATION IN SOUTH AFRICA

by

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DECLARATION

I declare that the study presented is authentic and original. It is submitted in partial fulfillment of the requirement for the degree of Masters Commerci (Informatics) at the University of Pretoria. This work has not been submitted before for any degree or extermination at any other institution or university.

I further declare that I have obtained the necessary authorisation to carry out the research. I declare that no unethical research practices were used or material gained through dishonesty.

Signed at Pretoria on the 31st day of August 2017.

Signature _____ (Tracy-Lee Alison Kotze)

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ABSTRACT

The most important strategic asset in an organisation is the knowledge its employees possesses. As a result, organisations are looking at various methods to retain and understand this knowledge in order to use as competitive advantage.

Requirements elicitation is the process where problems that need to be solved, are uncovered. The information that is gathered needs to be analysed, interpreted, modelled and validated before it can be utilised for Information Systems (IS) development. The development of an IS requires access to knowledge, whether the knowledge comes in an explicit or tacit form. Explicit knowledge is knowledge that can be expressed in words or numbers and can be easily articulated. Tacit knowledge is rooted in an individual's experience and has a personal quality; it is more difficult to articulate and communicate. The extraction of explicit knowledge can be made available with great ease, but there is some degree of tacit knowledge that cannot be encapsulated unequivocally and requires intervention to capture and apply knowledge.

The implementation of an IS follows a System Development Life-cycle (SDLC) approach. One of the critical activities in this process is the elicitation of requirements from stakeholders in this interactive process. Elicitation of requirements includes gathering information from users, validating and capturing the information to develop a requirements specification that will be used to develop an IS.

The purpose of this interpretive case study was to understand how knowledge can be captured effectively during requirements elicitation in the context of a high-reliability organisation (HRO). An HRO is an organisation that can perform optimally without accidents and have low safety rates over time. An analysis of requirements elicitation in the literature was produced and an online questionnaire was distributed to employees at a HRO in South Africa in order to collect data. Upon analysis of the findings, it was established that employees of this HRO has long tenure at the organisation and is willing to share knowledge. It was also observed that the standard system requirement process

does not cater for knowledge capturing as employees at this HRO environment often act based on their own experiences and tacit knowledge rather than explicit knowledge. There is a need to improve on the requirements elicitation process by providing an opportunity for the capturing of this knowledge in the requirements. The document produced after the requirements elicitation, is the software requirements specification document and a recommendation is made that this artefact should cater for the capturing of knowledge.

ABBREVIATIONS

ANSP	-	Air Navigation Service Provider
ATC	-	Air Traffic Control
BABOK	-	Business Analyst Book of Knowledge
ICAO	-	International Civil Aviation Organization
ICT	-	Information Computing Technology
HRO	-	High-Reliability Organisation
IIBA	-	International Institute of Business Analyst
IRD	-	Information Requirement Development
IS	-	Information Systems
ISD	-	Information Systems Development
IT	-	Information Technology
KM	-	Knowledge Management
RE	-	Requirements Elicitation
SACAA	-	South African Civil Aviation Association
SDLC	-	System Development Life-cycle

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Chapter 1 Introduction

1.1 Background

High-Reliability Organisations (HROs) strive to achieve problem-free performances under demanding circumstances. These organisations operate technical systems that are beneficial, but costly and hazardous, should major operational errors occur - the consequences are vast and catastrophic (Casler, 2014; Roberts, 1990). There are dual goals that need to be achieved by these systems; these are: to sustain delivery at maximum capacity, and to operate in a nearly error-free approach. Examples of HROs are nuclear power generation plants, air traffic control organisations, hospital emergency departments, and naval aircraft carriers. The employees of these organisations play a crucial role in helping organisations achieve high-reliability performances (Ericksen & Dyer, 2005; Yip & Farmer, 2015).

In 1984, three faculty members at the University of California Berkley, Gene I. Rochlin, Todd R. La Porte and Karlene H. Roberts, were tasked with studying flight operations at sea to understand how an HRO operates in extreme conditions (Hopkins, 2007). During the investigation, the researchers noticed that an airplane landing on the deck caused a constant loop of conversation amongst the aircraft team members. If you were not part of the team, the conversation might be incoherent. During this investigation, it was observed that seasoned personnel on site monitored the landing for deviation to the routine as opposed to listening to conversations. This is a safety critical activity that is monitored by different listeners on a vast number of communication channels. These channels are put in place to ensure that any critical element that is out of place will be discovered prior to a possible event that might cause problems (Rochlin, La Porte & Roberts, 1998). These routine activities, or procedures, are put in place to ensure HROs operate error-free, but should there be a deviation in the procedure, this is managed through knowledge earned through experience.

According to Weick, Sutcliffe and Obstfeld (2008), HROs operate under an “unforgiving social and political environment” (2008:32). The environment is rich with potential error and the scale of consequences makes learning through experimentation impossible. It is therefore necessary to have complex technology or IS in place to manage complex processes (Weick *et al.*, 2008).

The purpose of an IS is to meet the needs of the organisation. The requirements for the IS are based on the procedures and characteristics of the operational system (Davis, 1982). It is often difficult to obtain correct and complete requirement information, this can be attributed to three major factors: First, the interaction among users and analysts to define requirements consist of complex patterns; second, information requirements are complex and the variety is large; and third, there is a constraint on humans as information processors and problem solvers. These factors make it difficult to form complete and correct requirements for the IS and which suggests that there should be different approaches in determining requirements (Davis, 1982; Ghanbari, Similä & Markkula, 2015).

IS have evolved as a catalyst to solve problems in an organisation, as well as to promote information technology (IT) as a mechanism to provide the organisation with a competitive advantage (Jones & Arnett, 1993). The changes in systems have led to the role of the user progressing from involvement in system design to information content provider. This shift in the user role requires a concomitant change in how IS are conceptualised. The emphasis should be less on the systems and more on the information aspect which is the user’s view of information as an individual or corporate asset (Bano & Zowghi, 2013; Leidner, 1998).

The International Civil Aviation Organisation (ICAO) is a United Nations specialised agency, established in 1944 to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention) (ICAO, 2017). The convention has 191-member states and all the groups work together to reach consensus

on the international civil aviation Standards and Recommended Practices (SARPs) and policies to ensure “safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector” (ICAO, 2017). These SARPs and policies are used by the member states to ensure that the local civil aviation operations and regulations are in line with the norms and standards globally.

The South African counterpart to ICAO is the South African Civil Aviation Authority (SACAA), a Schedule 3A public entity in terms of the Public Finance Management Act (PFMA) (SACAA, 2017). This organisation was established on 1 October 1998 and is responsible for “controlling, promoting, regulating, supporting, developing, enforcing and continuously improving levels of safety and security throughout the civil aviation industry” (SACAA, 2017). This is achieved by complying the SARPs of ICAO within the South African context.

The focus of this dissertation is an HRO in South Africa, the organisation is an Air Navigation Service Provider (ANSP), and as part of the operation, adheres to the SARPs identified by ICAO.

IS developed in an HRO focus on the routine activities that take place in the organisation, but the day-to-day deviation of activities is not captured in the IS. These deviations occur apart from procedures and could provide valuable insight into this safety critical organisation.

1.2 Introduction

The field of IS emerged in the 1960s, evolving from computer science, accounting, management and organisation theory as well as operations research. These disciplines have their perspectives on applications of computers in the organisation, none of them focus on how computers are applied, and this emanated the field of IS (Hirschheim & Klein, 2012).

The development of a new system entails the identification of requirements and the codifying of organisational procedures and practices. Once in operation, IS affect the information processing patterns as well as the capacities of an organisation (Pentland, 1995). Tiwana and Mclean (2005) state that knowledge transfer is possible in the initial requirements analysis phase of systems development, however, the tacit components of knowledge is a less feasible mechanism for applying stakeholder's knowledge in the Information System Development (ISD) process.

To identify perspectives of knowledge, Alavi and Leidner (2001) are of the opinion that there is great emphasis placed on understanding the difference between information, data and knowledge, as well as drawing implications from the difference. The inference can be made that knowledge is personalised for individuals or groups to benefit from it, to others, there is a need to express it in such a manner that it is interpretable by those who receive it, and it is only information that has been actively processed by an individual through a process of enlightenment or learning that can be useful (Alavi & Leidner, 2001).

The elicitation of requirements for an IS is knowledge-intensive and a critical progression in the development of an information system. Poor execution of this process will result in project failure (Hickey & Davis, 2003a). This process determines and formalises the system requirements, and can be viewed as the basis for every project as it addresses and describes the needs of stakeholders in a potential new system, as well as what the systems should do to adhere to those needs (Azadegan, Papamichail & Sampaio, 2013). The requirements identified are abilities imposed on systems that are built to attend to the user's needs, and there is a challenge to understand a user's problem in their own language and culture (Bano & Zowghi, 2013; Kwon & Watts, 2006).

To define business requirements, an understanding of the domain knowledge is required and user requirements are gathered by user communication (Vásquez-Bravo, Sánchez-Segura, Medina-Domínguez & Amescua, 2014). The primary source of requirements when an IS is developed, is the people who either use the current system or those who

are expected to use the proposed system (Appan & Browne, 2012). The success of the Information Requirements Development (IRD) process is dependent on users and other stakeholders communicating correct requirements to the analyst (Appan & Browne, 2012). The external observable behaviours and characteristics of a software system is described in the software requirements document (Ding, Liang, Tang & van Vliet, 2014).

The approach that manages the knowledge assets of an organisation by capturing its experiences and insights is called Knowledge Management (Van den Hoven, 2001). The information is viewed as a preliminary stage to knowledge and is information with specific properties. The collection and dissemination of knowledge to the benefit of an organisation and individuals, is referred to as knowledge management (KM).

Software projects encounter many KM challenges, such as the distribution of knowledge, keeping knowledge up-to-date, soliciting feedback, and the organisation of knowledge for easy access (Treude & Storey, 2011). The elicitation of system requirements necessitates that stakeholders have a good understanding of their roles and duties in the organisation. The elicitation of requirements to develop IS follows a standard approach, where users or stakeholders are engaged and their needs assessed, elicited, and documented. The current elicitation process that is used in the establishment of user requirements to develop IS, does not focus on how organisational knowledge can be captured to ensure that knowledge (tacit and explicit) is harvested for intellectual assets in the organisation.

Organisational information and knowledge are not as readily available to decision makers because of the following reasons: First, the turnover of personnel creates great losses of the human component of an organisation's memory. Second, future needs for certain technological and organisational decision making is not anticipated, the result is a vast amount of knowledge that is not being stored or if stored, cannot be easily retrieved. Third, members do not share information easily (Huber, 1990; Mehta, Hall & Byrd, 2014).

A key concern for IS managers is the establishment of a strong alignment between IT and organisational objectives. (Benbasat & Reich, 2000) identify four factors that influence the alignment: One, shared domain knowledge between business and IT executives; two, the success of IT implementation; three, the communication between business and IT executives; and four, the connections between business and IT planning processes.

The business applications developed by IT should be partly owned by business management as they have a key involvement in the requirements definition. Their participation and ownership in the design and implementation are seen as a critical success factor of IT development (Lambert & Peppard, 1993).

Knowledge plays an important role when requirements are gathered and documented, the input is elicited from individuals and is based on their tacit and explicit knowledge. This dissertation aims to address the role of knowledge capturing during the process of eliciting system requirements in a high-reliability organisation.

1.3 Research problem and objectives

For organisations to compete effectively, they must use their existing knowledge and create new knowledge. This is a continuous dialogue between tacit and explicit knowledge (Nonaka, 1994). Based on the introduction, the objectives of this dissertation are:

- To determine how knowledge can be captured effectively during the elicitation of system requirements in an HRO.
- To identify knowledge artefacts during the requirements process and to show what constitutes effective knowledge capturing.

1.3.1 Problem statement and purpose of this study

The application and development of IT is important if a business expects to succeed and compete in the ever-changing field of IT (Hirschheim & Klein, 2012). The process of requirements elicitation during the development of an IS relies heavily on who knows

what, however, accessing these knowledgeable individuals can be difficult and, should they leave the organisation, valuable knowledge may disappear (Rus & Lindvall, 2002).

HROs are expected to react to unanticipated events. Plant outages can occur without warning, and changing weather conditions can put air traffic controllers in situations where they must think on their feet. In other organisations, failures can be measured in the balance sheet but failures in HROs show up in the balance sheet as well as in the eyes of survivors or next of kin of victims (Roberts, 1990). In other words, failure by HROs could lead to the loss in lives.

The elicitation of requirements is amplified in an HRO as it involves complex systems technology in complex environments. To perform in such environments, individuals must be aware of the proper tactics, procedures and rules. The limitation of human attention and working memory requires the development of relevant "long-term memory stores, goal-directed processing and automaticity of actions through experience" (Endsley, 1995; Endsley, 1999:260) to achieve successful performance in HROs.

"In most enterprises, structured data makes up only 10% of its data, information and knowledge resources; the other 90% exists as unstructured data" (Van den Hoven, 2001:82). All relevant knowledge that exists in the organisation should be taken into account when an IS is developed to ensure the organisation utilises its most significant corporate assets, knowledge, and intellectual capital. The more skilled individuals become in performing their tasks, the less aware they become of the cognitive process that is involved when they execute their duties.

Hickey and Davis (2003a) state that the requirements elicitation process is a series of activities performed to determine the need of the stakeholders. The authors developed a model for requirements elicitation and examined knowledge as part of the process but not how the knowledge will be captured as part of the elicitation process.

The purpose of this dissertation is to identify how knowledge can be captured during the requirements elicitation process, and to explore how the elicitation process can be enhanced to address HROs. Furthermore, the goal is to identify knowledge artefacts during the elicitation process.

1.3.2 Research Questions

Based on the purpose of the study, the main research question is:

- How can knowledge be captured effectively during the elicitation of system requirements in an HRO?

The secondary questions:

- What constitutes effective capturing of knowledge?
- How to identify knowledge artefacts during the elicitation of system requirements?

1.4 Rationale for this study

1.4.1 Scientific

In his book *The Tacit Dimension*, Polanyi (1966) states that “we can know more than we can tell” (Polanyi, 1966:4). Tacit knowledge emerges over time, and many times people are not aware that they possess this knowledge and this makes it difficult to express (Bloodgood & Salisbury, 2001). Chapter two of this dissertation explores the different facets of knowledge, it is a personal quality (Nonaka, 1994) and it needs to be captured to build on it and to incorporate it into the organisation (Gable, Scott & Davenport, 1998; Nonaka, 1994).

An important expectation of KM is that it deals with the complexity of how people use their minds, how they think and how they conduct their work (Wiig, 2000). One of these complexities is knowledge capturing. Explicit knowledge can be captured in some form or other and accessed by individuals, KM also deals with the capturing of tacit individual experience (Kebede, 2010; Tan, Carrillo, Anumba, Kamara, Bouchlaghem & Udeaja, 2006). The elicitation of requirements is an interactive process in which different

stakeholders engage to identify and validate the requirements of an IS (Pitts & Browne, 2004). It describes what the IS should do, the requirements are documented and validated during this process (Chikh, 2011).

Safety is not the primary objective of most organisations, it is to make a profit, provide a service or sell a product (Marais, Dulac & Leveson, 2004). System development in HROs include expectation from the stakeholders, political interest, the public and users of the system, these organisations requires a higher degree of reliability of their systems, errors are not tolerated (Sullivan & Beach, 2003). HRO's have complex systems, the individuals who work with the systems have good technical knowledge in the operational aspects, this could be seen as a technical predictability as they have become comfortable in the day to day operations (Marais *et al.*, 2004).

Chapter two looked at different techniques to capture knowledge, such as post-project reviews, communities of practice and after action reviews (Tan *et al.*, 2006). These techniques do not look at requirements elicitation as a tool to capture knowledge, the purpose of this study is to understand this gap and to understand the role of knowledge capturing during this process

1.4.2 Personal

During the development of an IS project at the organisation where the researcher works, a team looked at the technical solution that was developed and asked the question: "Where in this solution can we identify knowledge that could be useful in providing the organisation with a competitive edge?"

This question highlighted the fact that the IS the organisation is purchasing, is developed based on the requirements of international standards but for a South African company. The system that the organisation envisaged is an IS that could be used by any ANSP in any part of the world. A system that could be used by different ANSPs could give the organisation a competitive advantage. However, this is only true if measures are put in

place to ensure that the knowledge needed to build a system is in line with the needs of the aviation community, that it is recognised and that this knowledge (tacit and explicit) is harvested.

Air Traffic Management is a highly specialised skill. This knowledge resides in unstructured data within the organisation. In the implementation of new IS, the organisation relies on the input of individuals to ensure that the rules and regulations that the organisation is governed by, are adhered to. It is difficult to identify the knowledge that will contribute to the development of an IS that will allow the organisation to identify its knowledge.

1.5 Research Strategy

Qualitative research is used to collect, examine and interpret data to gain understanding, elicit meaning and develop knowledge (Lee & Xia, 2010). The data is expressed as words, images or objects (Neuman, 2014). Quantitative research examines the relationships among variables, these variables are measured on instruments that will allow the data to be analysed using statistical procedures (Creswell, 2014). When both quantitative and qualitative methods are used during research, this is referred to as mixed methods research (Saunders, Lewis & Thornhill, 2009).

The researcher followed a mixed method approach to gain an understanding on the role of knowledge capturing during requirements elicitation and to develop knowledge on how the elicitation of requirements can assist in knowledge capturing. "Qualitative and quantitative research used together produce more complete knowledge necessary to inform theory and practice" (Johnson & Onwuegbuzie, 2004:21).

Primary data refers to the data that has not been published and which the researcher has gathered directly from an organisation or from people (Myers, 2009). Secondary data is data is data that has been published such as journal articles, books, and so forth (Myers, 2009). Both these forms, with secondary data in the form of a literature interview, was collected and studied. "A literature review constructively informs the reader about what

has been learned" (Webster & Watson, 2002:18). It builds on the idea that we can learn from, as well as build on the work of other people. It rests on the premise that research is a collective effort where many researchers share their ideas (Neuman, 2014).

The researcher conducted the literature review on KM and its processes which includes the knowledge creation and knowledge capturing process; the researcher also provided a description of HROs. Further, the literature review was conducted on the requirements elicitation process, where it fits into the SDLC and how requirements elicitation is conducted.

The primary data was collected by means of a questionnaire consisting of open-and closed-ended questions to get an understanding of how the organisation captures knowledge during the elicitation of system requirements processes. The questionnaire was sent via email to 150 respondents. The probability technique with purposeful sampling was used and the respondents were identified by the researcher based on their role in the organisation. Sixty-four responses were obtained yielding a response rate of 43%. Once the questionnaires were returned, the data was analysed and findings produced.

The premise of this dissertation is based on the view that organisational knowledge is created through the process of eliciting explicit and tacit knowledge. It argues that new knowledge can be provoked, or existing knowledge can be collected during the elicitation process of the software development lifecycle. The theory of (Nonaka, 1994) explains how knowledge held by individuals can be distended and improved through the spiral interaction of extracting tacit and explicit knowledge.

1.6 Benefit of the study

IS are introduced into the organisation as needs change, when a problem occurs or to keep abreast with new technology. Each employee brings their own skill and experience when IS are developed, the information documented is what will be developed in the IS.

Unfortunately, the day-to-day application when employees are required to think on their feet is not captured.

Functionalities can be built into the IS, but the information and knowledge that provide a competitive edge and that make organisations stand out is the knowledge and skill contained in the individuals. This dissertation will provide an understanding of what role knowledge capturing can play when requirements are developed, to ensure that knowledge (tacit and explicit) is documented and captured and can be used to provide a competitive advantage.

This dissertation will also provide HROs with an understanding as to how they can ensure that the safety incidents and accidents that occur have been identified and it is captured, and how different individual reacted in certain situations.

1.7 Limitations of the study

Although the aims of the research were achieved, the researcher recognises limitations to the study. Firstly, other KM processes such as knowledge generation, knowledge distribution, and knowledge transfer were not taken into consideration and the research is only restricted to knowledge capturing. Secondly, the focus has only been on the requirements elicitation stage of the SDLC within one HRO in South Africa. Further research is required to generalise the findings.

1.8 Outline of the Study

The study is divided into six chapters with the following scope and contents:

Chapter 1 – Introduction. This chapter is an introductory chapter which highlights the objectives and background of the research, the research questions, and the proposed theoretical framework to be followed.

Chapter 2 - Knowledge Management. This chapter is focused on the process of KM and knowledge creation and capturing, understanding how this process is conducted and what it encompasses.

Chapter 3 - Requirements elicitation in relation to knowledge capturing. This chapter focuses on the elicitation of system requirements from users; it provides an understanding of the SDLC and where in the cycle elicitation is important. This chapter will have a strong focus on how the requirements elicitation process is conducted and what elements come into play during this process.

Chapter 4 - Research Methodology and Design. This chapter explains the research strategy, design and methodology used to perform the study. It also explains the data collection instrument and discusses the steps taken to ensure ethics and anonymity.

Chapter 5 - Analysis and Interpretation of the data. In this chapter, the data collected is analysed and interpreted.

Chapter 6 – Discussion and Recommendations. This chapter is a discussion of the findings of the research and offers a recommendation on the findings the data (primary and secondary) collected.

1.9 Summary

In this chapter, the background to the research topic was introduced through the discussion of the background of the problem, research methodology, as well as the benefits and limitations of the dissertation.

Chapter 2 Knowledge Management

2.1 Introduction

Roth (1997) embarked on a study that investigated decision making during an emergency in an HRO. In this domain, operators are required to follow the standard operating procedures to ensure that all relevant steps are followed during an emergency. During observation, (Roth, 1997) found the responses by employees in the situation was twofold. In the first situation, standard operating procedures were followed in reaction to the situation, in the second, the situation was assessed and the operators constructed a mental representation to identify malfunctions, anticipate future problems as well as evaluate the appropriateness of the steps. Roth (1997) observed that the efforts by the operators in the second instance who aimed to improve the situation were both social and interactive. Discussions were held to ensure the procedure will direct the operators to resolve the emergency. In a situation where an HRO encounters a problem and has no choice but to respond to the unexpected in real time, operators are dependent on their resourcefulness to take relevant action to resolve the said situation.

The dependence on own resourcefulness is emphasised by the concept of tacit knowledge, introduced by (Polanyi, 1966:4) that *"We can know more than we can tell"* (1966:4). In his explanation of the concept, Polanyi uses the analogy of face recognition. He asserts that we can recognise a face, yet we do not know how we can do this. Expert knowledge is tacit knowledge. The development of software requires the acquisition and transmission of knowledge (Ryan & O'Connor, 2009). This can be a source of competitive advantage because it enables organisations to apply important knowledge in their operational activities, which results in improved efficiency, value creation and improved financial performance (Arnett & Wittmann, 2014).

An important property of air traffic control is that "air traffic controllers are the technology", they issue instructions to the pilots by using standard phraseology and by allocating airspace (Weick, 1987:120). Users have a deep understanding of their domain, and they can explain their goals and how they approach their tasks. The use of documents as

sources of information is insufficient, it is direct contact with users that will conceptualise the various contexts in which systems will be used (Kujala, 2003).

2.2 Outline of Chapter 2

This chapter provides an overview and understanding of KM and its process. It focusses on knowledge capturing, the importance thereof as well as how it is captured. An understanding of HROs is provided, details of this type of organisation, as well as the characteristics thereof, are explained. This is considered in relation to the second research question "What constitutes effective capturing of knowledge?". Table 1: Outline of Chapter 2 provides an overview of the chapter layout.

Table 1: Outline of Chapter 2

Outline of Chapter 2			
Section	**Description**	**Sub-section**	**Sub-section description**
2.1	Introduction		
2.2	Outline of Chapter 2		
2.3	Knowledge Management	2.3.1	What is knowledge?
		2.3.2	Explicit and Tacit knowledge
		2.3.3	Data and Information
		2.3.4	Knowledge Management
2.4	Knowledge Management Process	2.4.1	Knowledge Creation
		2.4.2	Knowledge Capturing
2.5	High-Reliability Organisation	2.5.1	What is a high reliability organisation?
		2.5.2	What are the characteristics of high reliability organisation
2.6	Summary		

2.3 Knowledge Management (KM)

To define KM, a distinction between the concepts of data information and knowledge must be made. Data information and knowledge are non-interchangeable concepts, and it is important to understand the difference between these concepts to conduct KM successfully (Davenport & Prusak, 1998).

2.3.1 What is Knowledge?

Michael Polanyi was born in 1891 and died in 1976. He was a trained physician and then took up a doctorate in physical science. His interest extended beyond the domain of physical research and he embarked on studying economics and social theory (Innis, 1977). From 1946 he focused on philosophy and in 1948 he pursued a career in social studies. It was his contacts in the Soviet Union that led him to reflect on his studies of the role of the scientist in research, and this experience encouraged him to develop his theory of what is known today as “personal knowledge” (Blum, 2010:197). This led to Polanyi’s premise of “we can know more than we can tell”. He makes an example of teaching a driver the theory of a motorcar, emphasising that theory cannot take away the driver’s skill of driving the car (Polanyi, 1966:4).

According to (Anand & Singh, 2011b), the word knowledge can mean three things: First, it can refer to a state of knowing. This is what we are acquainted with and able to recognise in the form of facts, principles, techniques and methods. It is also referred to as “know about”. Second, knowledge refers to “know how”, this is our understanding and ability to grasp facts, principles, techniques and methods and apply what we know to make things happen. Third, it refers to knowledge that has been captured in the form of books, papers, formulae and procedures.

This knowledge is codified and captured as facts, principles, techniques and methods (Anand & Singh, 2011a). Knowledge is personified in human beings as their capacity to understand, explain and negotiate concepts, actions and intentions (Zins, 2007). It is now

universally recognised as a critical competitive asset (Ajmal, Helo & Kekäle, 2010), and cannot be created without individuals.

Knowledge is perceived as a source of power, as potential contributors of knowledge may distract themselves from knowledge exchange if they feel that there is more benefit in hoarding their knowledge, rather than sharing it (Kankanhalli, Tan & Wei, 2005). The development of information requirements for an IS is a knowledge-intensive process. There is a need for knowledge and expertise in the application of tacit and explicit knowledge, general and contextual knowledge, as well as the sharing of knowledge (Markus, Majchrzak & Gasser, 2002).

2.3.2 Explicit and Tacit knowledge

Knowledge can be grouped in two categories namely, explicit, or codified knowledge, which can be transmitted into formal systems, and tacit knowledge that has a personal quality and is harder to articulate, formalise and communicate (Nonaka, 1994).

Coakes (2004) claims that our minds follow a certain chain of thought and that knowledge is developed according to our own pre-set methods or formulas. Our experiences give us memories that guide and discipline us which allows us to understand new experiences. These life experiences, values and beliefs are stored in story form. Stories serve as a repository of knowledge and experience (tacit knowledge), and this is narrated in the form of storytelling.

Explicit knowledge refers to knowledge that can be expressed in words and numbers and can be easily communicated and shared. Implicit, or tacit knowledge, is rooted in an individual's experiences and it consists of the individual's schemata and perceptions, or worldview, and are not easily accessible (Koskinen, Pihlanto & Vanharanta, 2003). Explicit knowledge can be shared through an IT system, while tacit knowledge is best shared amongst individuals. The conversion of tacit knowledge as opposed to explicit

knowledge is a key process in the creation of new knowledge (Chyi Lee & Yang, 2000; Zack, 1999).

2.3.3 Data and Information

In elucidation of data and information, Ackoff (1989) states that data are symbols that represent the properties of objects and events. This is illustrated by analysing the census data collection process. Data collected from censuses is converted into information and presented in tables to indicate the usefulness of the data. The difference between data and information is functional, not structural. Subject to the context of its use, data has different definitions, for example, Information Science defines data as "unprocessed information" other domains describe data as "representation of facts" (Hey, 2004:5).

The intent of KM is to assist in achieving the strategic objectives of organisations. There needs to be a clear understanding of the difference between knowledge and information. Information is the fact and other data that is organised to characterise
a certain situation; knowledge is possessed by people's beliefs, truth perspectives and concepts (Wiig, 2000). Once knowledge is applied, it becomes experience, and this knowledge is much broader than information and data, it is contained in information as well as in the relationship of information (Rus & Lindvall, 2002).

2.3.4 Knowledge Management

KM is the extraction and leveraging of individual knowledge to allow knowledge to become available to the organisation. The knowledge becomes independent from a particular individual's as it requires turning personal knowledge into corporate knowledge in order to create resources that can be shared with the organisation (Anand & Singh, 2011a). This spontaneous unstructured knowledge transfer is vital to an organisation's success because it will develop dedicated strategies that will encourage impulsive knowledge exchanges with an emphasis on informal relations.

The Gartner group has defined KM as: “a discipline that promotes an integrated approach to identifying, capturing, evaluating, retrieving, and sharing all an enterprise's information assets. These assets may include databases, documents, policies, procedures, and previously uncaptured expertise and experiences in individual workers," (Duhon, 1998:10).

The effectiveness of KM is dependent on how new knowledge in an organisation is generated and how existing knowledge is transferred. The objective of KM is to combine intellectual resources and make it available to the rest of the organisation. Organisations often lose potential revenue because they are unaware of others’ knowledge and end up duplicating projects due to the lack of knowledge sharing and transfer (Rao, 2003; Zaim, 2006). A team is the interdependent collection of individuals that share the responsibility of explicit outcomes for their organisation (Sundstrom, De Meuse & Futrell, 1990). The tasks of project teams are time bound. Project teams produce a single output at a time, such as a new IS or a new product or service. Their tasks are mostly non-repetitive and require the significant application of expertise, decision making and knowledge across different disciplines and functional units (Cohen & Bailey, 1997). Knowledge sharing is key to the development of new outcomes. The members of the different functional areas can also search and retrieve knowledge from outside the teams to integrate with their existing knowledge (Mehta *et al.*, 2014).

The facilitation of knowledge between individuals to ensure the maximum amount of transfer occurs is a major challenge in KM. No single or optimal solution can be put in place to deal with the diversity of knowledge types. A variety of approaches and systems needs to be put in place (Bjørnson & Dingsøyr, 2008). The corporate memory of an organisation needs to be captured in such a way that knowledge can be built upon – an organised database infrastructure that is directed to enhance planning and decision making (Gable *et al.*, 1998). The most strategically significant resource of an organisation is knowledge, if organisations want to succeed in following their strategy, they need to integrate specialised knowledge possessed by individuals (Grant, 1996).

2.4 Knowledge Management Process

ISD projects require integrative collaboration and sharing of knowledge between business and technology. It is knowledge-intensive and requires continuous communication amongst stakeholders across different domains of the project (Lee, Park & Lee, 2015).
To improve how organisations conceptualise and manage organisational knowledge evidence, Evans, Dalkir and Bidian (2015) conducted an investigation on the KM life-cycle, their model is based on how often the models were used by practitioners, and the scholarly acceptance of the models. By integrating the KM life-cycles model, a comprehensive KM life-cycle model was defined. This model contains several phases, namely: identify, store, share, use, learn, improve and create. During the identification phase, a knowledge request is created. In this case, the searcher should identify if the knowledge is new or if it needs to be created. Once the knowledge has been created and identified, the knowledge can be stored and shared. Then, the value of the knowledge is expedited when it is activated and used. It can then be used to learn and improve.

Software development is knowledge-driven and relies on employees' expert knowledge to create a complete product. This knowledge is mostly tacit, lies in individual minds and can be the means of production in software development (Ryan & O'Connor, 2009). Avgerou (1987) states that the development of the requirements specification relies heavily on the capturing of knowledge of the people in the organisation. The needs and demands of people are captured and communicated to the developers as well as to the users.

The definition of knowledge from the perspective of the user is increasingly recognised by companies. The way value can be created during each stage of the KM cycle provides insight into how knowledge evolves (Birkinshaw & Sheehan, 2002). The ability to capture the right knowledge is important during knowledge capturing and this process comprises of two activities: One, the identification of knowledge that is critical to the organisation's

business operations, and two, the evaluation of the identified critical knowledge in order to decide whether to retain it for packaging and dissemination or not (Aggestam, Durst & Persson, 2014). Information Requirement Development (IRD) is the interactive process during which many stakeholders attempt to identify, establish and validate the requirements of a new system. It is the direct responsibility of the analyst to direct and control the IRD process (Pitts & Browne, 2004).

Alavi and Leidner (2001) state that KM is regarded as a process that involves four basic processes namely creating, storing/retrieving, transferring and applying knowledge. The development of new content or the replacement of existing content within the tacit and explicit knowledge of the organisation, is known as *knowledge creation*. Through this process, knowledge is created, amplified, shared and justified by the social, collaborative, as well as the cognitive processes of an individual.

The *storing and retrieving* of organisational knowledge is also referred to as organisational memory. This includes knowledge that resides in different forms, including written documentation, codified information stored in IS and processes, and tacit knowledge that has been attained through networks of individuals as well as individuals. *Knowledge transfer* occurs at different levels in the organisation: transfer of knowledge amongst individuals, from individuals to explicit sources, from individuals to groups, between groups and from groups to the organisation. Often organisations do not know what they know and have inadequate systems in place to locate and retrieve knowledge. Communication processes and information flows drive knowledge transfer. *Knowledge application* is a source of competitive advantage if knowledge is applied, rather than the knowledge itself being the organisation's competitive advantage (Alavi & Leidner, 2001).

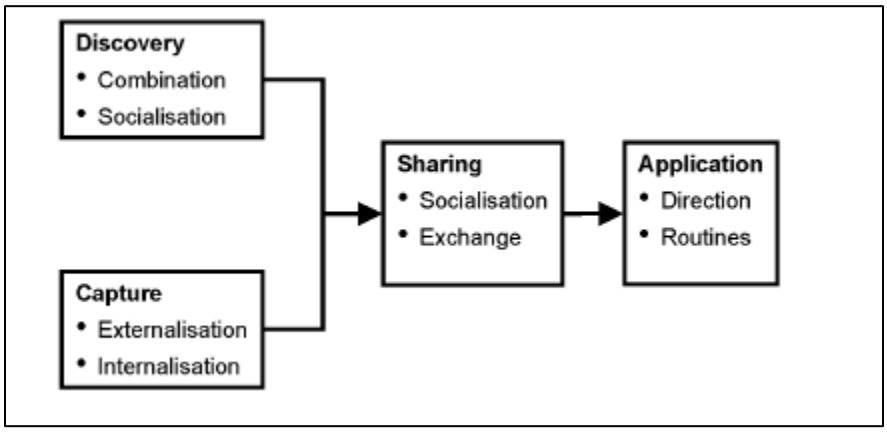

Figure 1: Knowledge Management Processes (Becerra-Fernandez & Gudi, 2008)

In Figure 1, Becerra-Fernandez and Gudi (2008) indicate four KM processes: the first process is that of knowledge discovery, this is the process of discovering new tacit or explicit knowledge from data, information or existing knowledge. The second process is the knowledge capturing process; this process refers to the retrieval of tacit and explicit knowledge that resides within people or the organisation. The third process is knowledge sharing; this process is the sharing of tacit and explicit knowledge through communication. The Fourth process can be described as the application process, whereby the knowledge available is used to enable decision making and individuals are able to perform tasks that have a direct influence on the organisational performance.

Knowledge capture and creation is a process in which knowledge identification, capture, acquisition, and creation are done (Rao, 2003). Knowledge creation provides the raw ideas and concepts that are transformed by the organisation into useful outputs. It starts out as an idea in someone's mind and gradually modifies and develops as it propagates throughout the organisation (Rao, 2003).

At this stage, the idea is conceivably abstract and many ideas will generate that will become clearer and better understood as the individual deliberates on these ideas (Birkinshaw & Sheehan, 2002). Individuals personalise knowledge for a trial that it is interpretable and accessible (Alavi & Leidner, 1999).

2.4.1 Knowledge Creation

Parsons (1938) identifies four principal functions of theory in research that provides an understanding of the importance of using theory research. Firstly, during research, we deal with many miscellaneous, mystifying facts that need to be consolidated. A theory provides us with selective criteria as to what is of importance and what can safely be ignored. Secondly, it provides a platform for the coherent organisation of the factual material identified, without which a research study is incoherent. Third, the facts which are known can be selected and organised in a manner that will guide productive research. Fourth, a theory consists of mutual logical implications of different analytical systems, and this can provide the capacity to generate new research as it reproduces a source of important related fields. This could lead to other developments which would not have taken place if it remained, theoretically, in isolation.

This dissertation will apply Nonaka's theory of organisational knowledge as a framework for observation and understanding of the phenomena in this research. According to Nonaka's theory, any organisation that deals with a dynamically changed environment will process information more efficiently and will create knowledge and information. Nonaka (1994) argues that the interaction of the organisation with its environment in combination with the means of how information and knowledge are created is more important when building an active and vigorous understanding of the organisation. The distinction between tacit and explicit knowledge is described as "the epistemological dimension to knowledge in the organisation" (Nonaka, 1994:15). There is a continuous dialogue about tacit and explicit knowledge that can drive and enable the creation of new ideas and new concepts.

Nonaka has identified four "Modes of Knowledge Conversion" (Nonaka, 1994:18). The first mode of knowledge creation is the conversion of tacit knowledge. This happens through interactions between individuals. In this mode, individuals share and understand

shared experiences of each other. This process of tacit knowledge creation is called socialisation, as it is difficult for people to share each other's thinking. The main task of requirements elicitation is to grasp and understand what users' or clients' needs are and to gather their initial demand (Liao, 2013). This process, or phase, in the SDLC derives information from individuals as well as other sources in the organisation. This process requires of the analyst to engage with the users or individuals. During socialisation there should be shared experiences, thus the need for individuals to collaborate. This is a process of two-way communication because elicitation is not an isolated activity.

The second mode of knowledge conversion is known as externalisation. This is the process of creating explicit knowledge from tacit knowledge. This mode involves the process of individuals articulating tacit knowledge through reflection and dialogue. Knowledge is exchanged through mechanisms such as meetings and telephonic conversations.

The third mode of conversion is the process of converting explicit knowledge to explicit knowledge. Explicit knowledge is the knowledge that has been collected inside or outside the organisation; it is then combined, edited or processed to form more complex and knowledge. This new explicit knowledge is then distributed to members of the organisation this is referred to as the Combination mode.

The fourth mode, Internalisation, is the conversion of explicit knowledge that has been created and shared in the organisation and converted to tacit knowledge. In this stage, knowledge is applied and used in practical situations and in the process, forms the base for new routines.

If the process is successfully iterated, it forms a spiral, and each twist of the spiral can strengthen the knowledge of the organisation to a higher knowledge-creating entity. This is a process that can move from the individual to groups then to the organisation as well as to a community of organisations. Interpretive researchers work with the assumption

that reality can only be accessed through social constructions and the philosophical bases are hermeneutics and phenomenology (Myers, 1997). The data gathered from the data collection is based on users in the organisation and their experiences on how they manage the organisation's knowledge.

2.4.2 Knowledge Capturing

2.4.2.1 What is knowledge capturing?

The experiences and knowledge that has built up over time by teams need to be captured to improve the quality as well as the effectiveness of future projects (Matsumoto, Stapleton, Glass & Thorpe, 2005). Individuals build their perspectives of the world through the interaction of knowledge, experiences and rationality. Individual perspectives remain personal unless they are articulated through social engagements and interactions (Nonaka, 1994).

Knowledge sharing is based on two strategies: First, the codification strategy that stores the knowledge in databases and archives where it can be used and reused. Second, the personalisation strategy where knowledge is tied to the people who developed it and is shared by personal interaction (Ruuska & Vartiainen, 2005). Capturing of knowledge can refer to the creation of knowledge from data where possible, as well as to what information should be added to the system. The conversion of personal knowledge to group available knowledge can be viewed as a key problem for knowledge management (O'Leary, 2002).

The process of knowledge capturing, elicitation and storing of organisational and individual knowledge is therefore designed to elicit both tacit and explicit knowledge (Becerra-Fernandez & Gudi, 2008). During knowledge capturing, knowledge is converted from tacit to explicit form and vice versa, and this is done through the process of externalisation and internalisation. Externalisation is the process whereby an organisation's tacit knowledge is captured. This is the knowledge possessed by the employees, and it is often difficult to articulate. Internalisation is the process through which employees obtain tacit knowledge.

The knowledge capturing process comprises of three sub-processes: One, identification of knowledge; two, representation of knowledge; and three, validation of knowledge. The identification and locating of knowledge deals with the identification of the type or categories of knowledge that should be managed, as well as the location of learning situations where new knowledge is being created and engagement with people is encouraged (Tan *et al.*, 2006). The representation and storing of the knowledge takes place once the knowledge has been captured, it needs to be indexed, organised and structured into theme specific knowledge areas and authored in the standard specified, adding context to where the knowledge was generated and where the knowledge will be useful for future utilisation (Tan *et al.*, 2006).

The validation of knowledge – the intention of this process is to ensure the credibility of the knowledge captured and that it is stored in the context and format that is required (Tan *et al.*, 2006). This codification of knowledge can reduce the dependency between expert groups (Kotlarsky, Scarbrough & Oshri, 2014).

2.4.2.2 The importance of knowledge capturing

Organisations require employees to periodically summarise their experiences to capture knowledge, and this can be done via writing articles or speaking at conferences, but this information is not a true reflection of how knowledgeable the individual is about to a topic (Bednar, 1999). To gain the most valuable knowledge, it is better to interview people face-to-face instead of asking them to relate their own experiences. Some organisations appoint journalists to interview their employees if they are looking for information. Knowledge and wisdom that has accumulated through thoughts, work and experiences are passed on to generations by telling stories (Smith, 2001).

The actions and behaviour of knowledge carriers manifest tacit knowledge. There is a need to have structures in place that will enable and encourage members of the organisation to interact and observe each other (Aggestam *et al.*, 2014).

HROs are IT-intensive organisations, and aviation safety systems are designed to prevent crashes and incidents and learnings from hairbreadth situations. The system in place is dependent on airline and aircraft manufacturers to share their knowledge with federal regulators (Balthazard & Cooke, 2004). These authors further state the initial process of knowledge management is dependent on harvesting the tacit and explicit knowledge, but the holders of the knowledge should be susceptible to support this harvest.

Experts have knowledge of a subject that has been developed over time. They have been tested and trained by experience and can view and understand new situations and events from a historical perspective. Familiar patterns are recognised, and they can form connections between what is currently happening and what happened in the past (Davenport & Prusak, 1998). Employees who are bearers of tacit knowledge might be oblivious to the existence of what they know and could find it difficult to articulate. This knowledge might be expressed in terms of a restricted code that forms part of a routine that is not codified according to (Bloodgood & Salisbury, 2001). Knowledge-based change is powerful for a strategic change. When individuals start to work in an organisation, they learn from others via a process of osmosis. These shared beliefs and assumptions can be equated to tacit knowledge, and it strengthens the unwritten and informal behaviour in an organisation that it needs to evolve (Balogun & Jenkins, 2003).

Tacit knowledge emerges over a period and is learned by engagement instead of memorisation. The routine engagements are not codified as it occurs through institutionalised interaction in an organisation. This can lead to products or services that are difficult to reproduce, because competitors will not be able to imitate the manner in which the knowledge was created (Bloodgood & Salisbury, 2001).

Knowledge is perceived as a source of power. There is a possibility that the bearers of knowledge will hoard what they know if they sense that they can benefit from it, (Kankanhalli *et al.*, 2005).

2.4.2.3 The identification of knowledge

Knowledge shared is knowledge doubled. Value creation is determined by the tacit and explicit transfer of knowledge between individuals and how knowledge is converted from one form to another (Sveiby, 2001). The identification of a solution is preceded by the characteristics that identify the problem and the elements of the solution. It is the sharing of common knowledge that facilitates the transfer of knowledge within groups (Kogut & Zander, 1992).

There has been critique with regards to the concept of KM in IT. Hislop (2002) believes if explicit knowledge cannot be managed independently, IT will have an insignificant role in KM. According to Hislop, the intrinsic characteristics of knowledge does not make integration into IT easy. The tacit and explicit component of knowledge is deeply entrenched in the activities that people undertake. These activities can be socially constructed to an extent, as it is embedded in the social values and cultural contexts. The introduction of IT will not transfer tacit elements. McDermott (1999b) concurs with this argument and states that if people who work in a group do not already share knowledge, and are not aware of the insights and information that could be mutually beneficial, IT is not likely to create this sharing of knowledge.

To facilitate the exchange of knowledge, it is important to identify the existence thereof. Expert knowledge is mostly tacit, and therefore knowledge sharing is a key process in the development of software systems (Ryan & O'Connor, 2013). Codified knowledge is important for finding nuggets of corporate wisdom, but a great deal of corporate knowledge is uncodified. It is useful to find expertise that is still embedded securely in the mind of the expert (Ruggles, 1998). The challenge in most knowledge management efforts lies in getting people to articulate and share what they know and do, and how they do it. Most knowledge management efforts treat these interactions as secondary and focus on IS, what information to capture, the construction of taxonomies and the determination of access (McDermott, 1999a).

2.4.2.4 How is knowledge captured?

Tacit knowledge needs to be identified before it is captured. It is widely accepted that the most valuable knowledge possessed by organisations is not those in written procedures but in the heads of long serving staff. This knowledge includes best practice as well as wisdom (Kingston, 2012).

There are several ways to capture knowledge: one of these is *lessons learned*. This term is used to describe truths in real situations on a personal level. There is a description of what happens “on the ground”, rather than a generalised point of view. Through this process, knowledge is transferred to other people, which will enable them to understand lessons learned from different situations (Davenport & Prusak, 1998). Lessons learned includes the process of how lessons are to be collected, verified, stored and distributed to be utilised in the organisation (Becerra-Fernandez & Gudi, 2008). These authors also mention *after-action-reviews* which involve an analysis of what was supposed to happen in a situation versus what actually happened, understanding and making sense of the differences and learning from the disparities.

People with technical knowledge are considered unconsciously skilled. Their knowledge is of such a nature that they are unaware of their good capabilities. An example of this is how an inexperienced manager will handle a difficult employee with tacit knowledge, common sense and diplomacy, an experienced manager will reinforce openness and provide opportunities that will increase knowledge sharing (Smith, 2001).

Capturing knowledge provides organisations with an opportunity to not re-invent the wheel but to utilise the existing knowledge that resides within the organisation. There are KM tools that can be used to capture and share knowledge. These are categorised as KM techniques and KM technologies (Tan *et al.*, 2006).

Table 2: KM tools and techniques

KM Tools	KM Techniques
Post project reviews	Groupware
Communities of Practice	Custom-designed software
Documentation of knowledge	Expert Directory
Training	Project extranet
Forum	
Recruitment	
External source of knowledge	
Reassignment of people	
Research collaboration	
Partnership-like arrangements	
Preparation of standard reusable details	
Research & development	
Team meetings, road shows, presentations and workshops	
Knowledge team	
Succession management & mentoring	

A Post Project Review is a formal review of the project which endeavours to examine the lessons that might have been learned and/or can be learned and used to benefit future projects (Von Zedtwitz, 2002). These reviews take place after the project is concluded. The time-lapse between the creation and the capturing of knowledge leads to the loss of insight that could have contributed to the knowledge of the organisation (Tan *et al.*, 2006).

Communities of practice is a network of knowledge of informal groups of professionals that are involved in a specific domain; and share passion and expertise for that domain; These communities can emerge formally or informally (Alavi, Kayworth & Leidner, 2005). It is a powerful tool to use for knowledge sharing, however, this tool is passive in nature

as, if a question is not asked, knowledge relating to the question will not be shared (Tan *et al.*, 2006).

The knowledge that is captured from trainings team meetings and presentations and workshops are usually captured by those trainers and participants and are topic specific, based on what was handled and discussed in the specific event (Tan *et al.*, 2006). Project extranets are used to share documented or explicit .

Knowledge can be received from external sources. These are sources that are out in the public domain or that do not come from the organisation. It has a cost saving benefit, however, it is usually project knowledge rather than detailed reusable knowledge for the organisation that has been identified (Tan *et al.*, 2006).

2.4.2.5 How is knowledge stored?

Tacit knowledge can be stored in the form of knowledge audits, knowledge maps, models and taxonomies but this is not a random collection of knowledge, it must be stored in a structured way that will allow the knowledge to be efficiently retrieved manipulated and eventually shared (Evans *et al.*, 2015). The management of explicit knowledge uses four resources: One, repositories of explicit knowledge; two, refineries that can be used for collecting, refining, managing, and distributing the knowledge; three, the organisation roles that execute and manage the refining process; and four, information technologies that provide support for the processes and repositories (Zack, 1999).

The professional intellect of an organisation can operate on four levels: The first, *cognitive knowledge* (or know-what). This is the mastery that has been achieved through training and certification, this is essential knowledge but will not provide commercial success to the organisation. The second, *Advance skills* (or know-how*).* This is when “book-learning” has been translated to execution, and the rules that were learned can be applied. The third, *Systems understanding* (know-why). This is when a professional has a deep

understanding of the domain, they have the "know-why" and can create extraordinary value and can move beyond the execution of tasks. The forth is s*elf-motivated creativit*y (care-why). This is the will, motivation and adaptability to be successful, these groups outperform other groups with the self-motivated creativity (Quinn, Anderson & Finkelstein, 1998:72).

2.5 High Reliability Organisations

2.5.1 What is a High Reliability Organisation?

High reliability is the ability of complex, high-risk industries to perform for long periods of time without accidents, they have a commitment to zero harm and the focus is on prevention, not reaction (DuPree, 2016).

In 1980, a group of researchers at the Berkley campus of the University of California initiated the term HRO. During their observations, they noticed that there had been research on organisations that experienced disasters but not a lot about organisations that, despite highly dangerous technologies, still function without a catastrophe. Their explanation of an HRO was that within a group of hazardous organisations, there is a subset of the group that had a record of high safety over time. This subset can be identified by answering this question: "How many times could this organisation have failed, resulting in catastrophic consequences, that it did not?". If the answer to this question was tens of thousands of times, the organisation could be defined as "highly-reliable", hence the term High Reliabilty Organisation (Hopkins, 2007:4).

2.5.2 What are the characteristics of a High Reliability Organisation?

Weick and Sutcliff (2002:2) identify five characteristics of HROs. The first is defined as "a preoccupation with failures rather than successes" (2002:2). HROs value the reporting value of near-misses and errors that occurred, these errors and failures are investigated and analysed as these are opportunities for improvement. "HROs foster effectiveness under trying conditions" (Weick *et al.*, 2008:2). That means non-HRO organisations focus more on failures than successes. The second characteristic is a *reluctance to simplify*, this refers to an HRO's ability to collect and review all warning signs and to not make

assumptions regarding the impact these may have. These organisations refrain from simplifying situations as this would increase the likelihood of an eventual surprise and it would limit the precautions that people would take if they envision desired consequences (Weick *et al.*, 2008).

The third characteristic is that HROs have a heightened *sensitivity of operations*, this is the ability to obtain and maintain the bigger picture of operations and have the ability to prepare and anticipate potential failures (Weick & Sutcliff, 2002). The fourth characteristic is the *commitment to resilience,* HROs can effectively anticipate errors but can also cope and bounce back from errors (Weick & Sutcliff, 2002). *Deference to expertise* is the last HRO characteristic, during standard operating procedures, HROs are hierarchal and all roles and responsibilities, as well as lines of reporting, are defined and followed. However, should an emergency occur, this structure will cease to exist, and decision-making is deferred to those individuals with expert knowledge on how to deal with the specific situation (Weick & Sutcliff, 2002).

One of the important elements in an HRO is safety; this is driven by the safety culture of an organisation which is the product of the individual and group patterns of the individuals (Cox, Jones & Collinson, 2006).

Unlike other organisations, HROs do not have trial and error learning, they have been prepared to increase their performance at any time and maintain operational effectiveness in the process (Weick, 1987). This drive for operational effectiveness is the result of a stable technical process that has been put in place and is well understood within the environment (Porte & Consolini, 1998). These authors conducted an investigation on an air traffic control system and observed what they referred to as three modes of organisational behaviour that ranges from routine to high-tempo to emergency mode. Routine mode is the familiar mode that involves standard operating procedures in which the air traffic controllers conduct routine operations. The second, high-temp mode,

emerges when the demand peak increases. An air traffic controller might have a more intense time period controlling a flight depending on the time of day. During this mode, there is a need for rapid adjustment in the functional process and organisational norms will kick in. Emergency mode is referred to when an event constitutes an emergency, in which case carefully constructed practices and operations will be activated. The operators will have a repertoire of how to act in these situations, this response is based on operators' experience and knowledge.

Air Traffic Control (ATC) is a safety critical system that involves high risks, the air traffic controllers hold the fate of thousands of people in their hands, a mistake that could result in a crash is unacceptable and their work practice requires rapid responses to conditions that can change at any time (MacKay, 1999). Real-time problem solving in combination with human knowledge is required to operate air traffic control (Kuwata & Oohama, 1997).

Systems used by HROs are highly technological, large and complex, these systems do not function in isolation, it is the collaboration and interaction of humans and technology that delivers the desired outcome of the system. An air traffic control system operates in a social-organisational environment, dependent on the behaviour humans and not solely on the technical artefacts (Qureshi, 2007).

2.6 Summary

This chapter relates to the first research question "What constitutes effective knowledge capturing? The focus of the chapter was on the nature of knowledge, KM, knowledge processes and knowledge capturing.

There is a description of the nature of knowledge with an emphasis on Michael Polanyi's premise "we can know more than we tell". The nature of knowledge was explored leading to the idea that knowledge is personified in human beings and can be perceived as a source of power.

Knowledge was further explored through analysis of tacit and explicit knowledge. Tacit knowledge that resides in people's heads is more difficult to extract than the explicit knowledge that can be documented because it is formalised. The objectives of KM were explored and it became clear that knowledge sharing is key to the development of new outcomes. Nonaka (1994) SECI model illustrates how knowledge can be created through Socialising, Exploration, Combination and Internalisation. The spiral of knowledge creation was explored and the alignment with SDLC is discussed.

The KM Process illustrates that it is important to capture the correct knowledge to create value. Knowledge capturing is only effective if the knowledge has been identified as critical and the identified knowledge has been assessed to see if it needs to be retained. From the literature studied, requirements elicitation is not one of the KM techniques.

The next chapter will focus on requirements elicitation and will address the first and third research questions, how can knowledge be captured effectively during the elicitation of system requirements in a high-reliability organisation? And how do you identify knowledge artefacts during the elicitation of system requirements?

Chapter 3 Requirements Elicitation

3.1 Introduction

The purpose of this chapter is to understand the process that is followed when IS are developed, specifically an SDLC focusing on one of the phases in the SDLC, namely the elicitation of requirements from system users to ensure that the IS required meets the user's needs. SDLC is a framework that describes and identifies the activities to analyse, build, deploy, and maintain IS (Satzinger, Jackson & Burd, 2011).

There are different approaches to the SDLC; therefore there is a need to describe some of the basic SDLC found in practice. There are three major phases that guide the SDLC, these are: The definition phase, which consists of a preliminary analysis, a possible feasibility study and analysis and design of the information at hand. The second is the construction phase, which entails the building and testing of the IS. The implementation phase, the last of the three major phases, handles the testing, training and deployment of the IS (Ahituv, Hadass & Seev, 1984).

Individuals develop sequential patterns of interaction that involve the integration of their specialised knowledge, the need to communicate is not necessary, this coordination relies on informal procedures that is in the form of commonly understood roles, and this is established through constant repetition and implicit and explicit signals (Grant, 1996).

IS contain information that is useful to organisations as it assists with decision making and control. The knowledge embodied in IS develops in the analysis and design of business systems, the reality is constructed in the interactions between business representatives and IS representatives (Jackson & Klobas, 2008).

"The software development process involves complex problem solving that is based on previous experience, the team members have specific individual expertise that is embodied by the conceptual understandings and the cognitive skills of the team" (Ryan & O'Connor, 2009:231). Working across boundaries between disciplines or

specialisations is a key ingredient for competitive advantage. There are three different perspectives of boundaries, these are: An *information processing approach*, where knowledge is viewed as something to store and retrieve information; an *interpretive approach* intensifies the position of actors having a common meaning to understand and share knowledge; and a *political approach* that realises that different interests encumber knowledge sharing (Carlile, 2004) .

The ability for an organisation to compete is not so much about how an organisation performs, but how it performs with cross-functional teams that are created in response to the pressures (Holland, Gaston & Gomes, 2000). These authors further state that members of these teams identify strongly with their function on a social as well as psychological level, cross-functional teams are likely to be temporarily assigned to a task and the team is faced with high performance expectations, they are expected to compress development time, to create knowledge and enhance organisational learning.

3.2 Outline of Chapter 3

This chapter provides an overview and understanding of the SDLC and the requirements elicitation process. The techniques which are used during requirements elicitation are described, as well as the role of the analyst and the knowledge capturing activity during this elicitation process.

Table 3: Outline of Chapter 3

Outline of Chapter 3			
Section	**Description**	**Sub-section**	**Sub-section description**
3.1	Introduction		
3.3	Systems development Life cycle	3.3.1	Analysis Phase
3.4	Requirements Elicitation	3.4.1	The requirements elicitation process

		3.4.2	Techniques in elicitation of requirements
		3.4.3	The role of the analyst in the elicitation process
		3.4.4	Knowledge capturing during requirements elicitation
3.5	Summary		

3.3 System Development Life-cycle

The first widely recognised historical treatment of the field of Management Information Systems was first published in 1981 by Gary Dickson. This field is now commonly referred to as IS (Hirschheim & Heinz, 2010)

The SDLC is a general approach to developing systems; it has been the basis of many software development projects since the 1970s (Avison & Fitzgerald, 2003). Avison and Fitzgerald (2003) explain the SDLC further by stating that it has, generally, the following structure: Firstly, a *feasibility study* is conducted to look at the present system as well as the requirements that it was intended to meet, and investigate alternative solutions if the needs have change. Secondly, once approval has been provided that a need exists, a *system investigation takes place*, this is a detailed fact-finding process that includes the functional requirements of the current system and the development of requirements for the new system. This investigation can be conducted in several ways, including observation interviewing, questionnaires, searching documents and sampling. Once the facts have been gathered the analyst proceeds with the *system analysis* phase, this is an attempt to understand all aspects of the present system and how to improve on it. The next approach is the *system design* approach which involves the design of the manual and computer parts of the system. After the design phase, the *implementation* process can commence, this includes the design and coding of the application or the procurement of a new system, after which the system is tested and deployed. The final stage in the SDLC is the *review and maintenance* of the system, during this phase,

continuous monitoring of the system takes place, and should there be changes, they are addressed.

Until the 1960s, computer applications were implemented without the aid of explicit methodologies, the emphasis was technical rather than focusing on the users, programmers had difficulty communicating with users and this led to the realisation that there is a gap that concerns system analysis and design (Avison & Fitzgerald, 2003).

System development methodologies are used to improve the process and products of systems development and are viewed as one of the core issues in the IS field (Fitzgerald, 1998). There are different methodologies used to implement new IS, these methodologies utilise structured methodological approaches to develop these IS. Structured methodologies are used as they: (1) subdivide development and management processes in probable and coherent steps, (2) provide an increase in transparency that controls the development process leading to risk reduction and uncertainty, (3) provides a goal-oriented framework that steers the application of resources and techniques in the right direction during the development and management process, and (4) enables the standardisation of the development and management process (Mohan & Ahlemann, 2013). A methodology is designed to enforce discipline in the software development process with the objective of making the process efficient and predictable (Khan & Beg, 2013).

Many models describe the phases of the system's life-cycle; these models have similar patterns that are followed to execute the development of an information system. The traditional software development process follows a sequence of processes that are commonly called the Waterfall model (Hickey & Davis, 2003b). Figure 2 below illustrates the waterfall approach of software development and shows the phase-wise development in linear form. In this model, the system does not return to the initial development cycle except when maintenance is required. Another model is an Iterative model, also known as an agile model, illustrated in Figure 3 below. With this model, once

a part of a system is developed it starts with the operational cycle, simultaneously another part of the system is developed, this continues until the end of development (van Slooten & Schoonhoven, 1996).

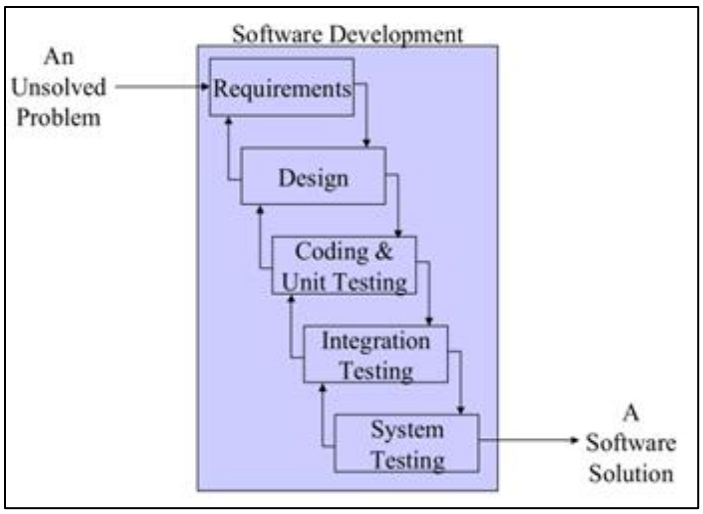

Figure 2: Waterfall Approach of Software Development (Hickey & Davis, 2003b)

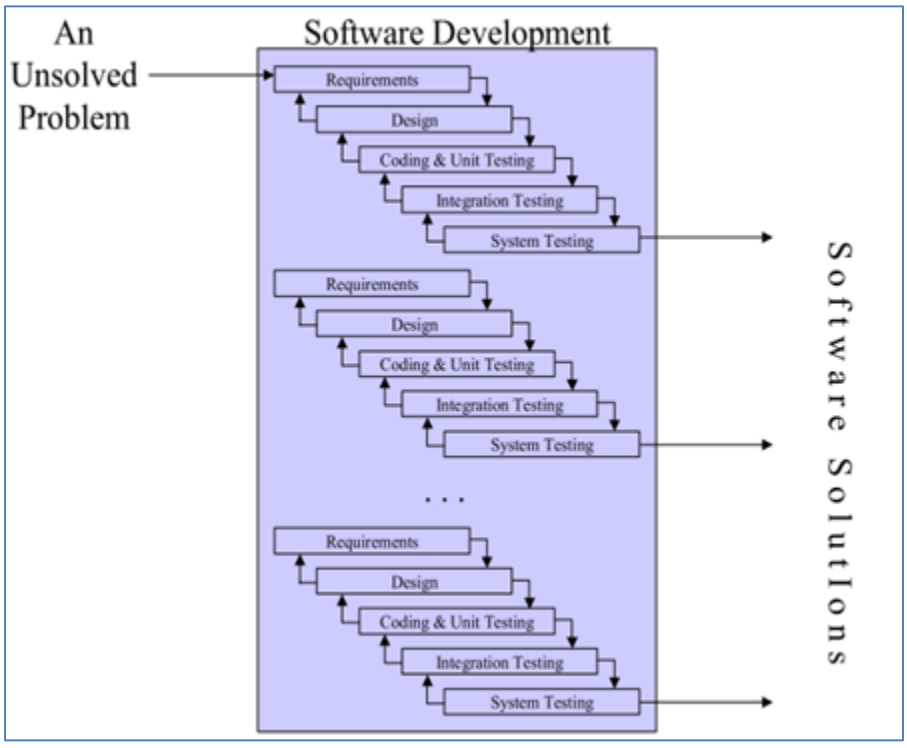

Figure 3: Iterative model of software development (Hickey & Davis, 2003b)

Software development is knowledge-intensive, the process creates and shares knowledge when different facets of a methodology (concepts, product, tools, process, people) interact with one another (Qumer & Henderson-Sellers, 2008). Software development is knowledge-driven and relies on employees' expert knowledge to create a complete product, this knowledge is mostly tacit and lies in individual minds and can be the means of production in software development (Ryan & O'Connor, 2009).

Software development teams can cope with the unpredictable and constant changing IT environment by using agile methodology as this is argued to provide flexibility (Liao, 2013). System methodologies have evolved; agile methodologies introduced an incremental and iterative approach to system development. In theory, it seems that this approach can reduce misinformation as there are ample opportunities for feedback from the user. Knowledge sharing enables software organisations to: effectively share domain expertise between the customer and the development team; identify the requirements of the software system; capture non-externalised knowledge of the development team members; bring together knowledge from distributed individuals to form a repository of organisational knowledge; retain knowledge that would otherwise be lost due to the loss of experienced staff; and improve organisational knowledge dissemination (Ryan & O'Connor, 2013).

The complex and dynamic nature of the software development process involves technological and organisational factors for management (Zowghi & Coulin, 2005). Management and exchange of knowledge are important in every software organisation, the software development process is knowledge-intensive (Treude & Storey, 2011).

ISD projects require integrative collaboration and sharing of knowledge between business and technology, it is knowledge intensive and requires continuous communication amongst stakeholders across different domains of the project (Lee *et al.*, 2015). Stakeholders in an ISD project share explicit and tacit knowledge, this allows stakeholders to learn and access knowledge from each other as well as different domains.

According to Lee *et al.* (2015), knowledge transfer is possible in the initial requirements analysis phase of systems development. However, the tacit components of knowledge is a less feasible mechanism for applying stakeholder's knowledge in the ISD process (Tiwana & Mclean, 2005). Communication leads to mutual understanding or alignment, information is shared amongst participants to reach a mutual understanding. The sharing of information over time leads to the participants converging or diverging from each other in their mutual understanding of a topic (Benbasat & Reich, 2000).

This dissertation focuses on the analysis phase of the SDLC process as this is the process where requirements for systems are gathered.

3.3.1 Analysis Phase

The determination of requirements occurs in the analysis phase of the system development process and can be viewed as a step by step process: First, the gathering of information by the analyst from the users; second, the representation of the elicited requirements by the analyst; and third, the verification process whereby the analyst

verifies that the requirements are correct. The focus of this research is concerned with the first step, the elicitation of requirements (Browne & Rogich, 2001). Organisations are constituted in the form of departments (Arora, 2002). These units work separately and have semi-permeable boundaries when information and knowledge flow between the departments are of concern, departments might feel threatened should they share information or it is possible that people want to share information but there is no disciplined process of sharing knowledge (Arora, 2002).

The analysis phase, or process, determines the content of the IS. It focuses on the problems that need to be solved, the rules that need to be put in place and solutions that need to be addressed in the organization. Bento (1994) identifies four strategies for determining system requirements, these are: asking, deriving, synthesis and experimentation. During asking, users are encouraged to indicate what they do and what

information they need to address their need, the analyst obtains requirements by asking the relevant questions. Deriving from an existing IS involves using existing IS information to gain requirements, there are different types of information systems that can be used to derive information from: existing systems that needs to be replace by a new system; systems that is used in other organisations; new systems; and information and descriptions from industry experts, textbooks, or other information. Synthesis comes from users that is already using an IS, requirements are developed from the characteristics of the current system. Experimentation can be used when users are not sure what they require from an IS, the requirements can be gathered based on what they think they will need, the IS is developed, and changes to the IS can be implemented later (Bento, 1994).

3.4 Requirements Elicitation

The success of systems development is highly reliable on the accuracy of requirements gathered during the requirements process (Hickey & Davis, 2004). This critical activity requires the correct identification of stakeholders to ensure that the accurate needs and expectations are identified (Pacheco & Garcia, 2012).

It is difficult to codify knowledge. According to Nonaka (1994), the process of socialisation is required to transfer knowledge from one person to another. The management of this process is through the requirements engineering process that comes from the software development domain and is concerned with the “elicitation, documentation, analysis, evaluation, negotiation and management of requirements” (Wellsandt, Hribernik & Thoben, 2014:213). This discipline came about when it became apparent that the quality of requirement specifications was crucial to prevent software failure (Pacheco & Garcia, 2012).

Requirement elicitation is the extraction of user requirements form different sources and consist of different steps to enable the process (Wellsandt *et al.*, 2014). It is also the activity where the problem that needs to be solved is uncovered, and where stakeholders

are identified to establish the relationships required to conduct the activity (Pacheco & Garcia, 2012).

The process by which system analysts acquire an understanding of a problem to be solved is called the information requirements determination, this provides the definition of the user needs and expectations for a proposed IS (Pitts & Browne, 2004). In an organisation, there are problems or opportunities identified that require an information system to improve the situation or adhere to the business needs.

The term “elicitation” is preferred to the term “capture”, as this would suggest that requirements are in the organisation to be collected, by simply asking the right questions, the information that is gathered often needs to be analysed, interpreted, modeled and validated before it can be used for system design and development (Nuseibeh & Easterbrook, 2000).

This multifaceted and iterative activity relies heavily on the communication skills of the analyst as well as the cooperation of the stakeholders, a major problem faced by software development teams are communication barriers and agreement on requirements (Zowghi & Coulin, 2005). IS specialists are agents of change in an organisation in the following ways: (1) New IT is an attempt to create change, this cannot be achieved by the IS specialist alone, it requires input and cooperation from executives, managers as well as individual users to achieve IT implementation success. (2) Change agentry will become one of the most important interorganisational IS work in the future. IS work that requires loyalty and insider knowledge – personalities, business processes, culture and politics – are essential or advantageous when change is introduced. (3) The introduction of change successfully will improve IS specialist credibility in the organisation (Markus & Benjamin 2012).

The requirements elicitation process focuses on gathering requirements from users that will allow the visualisation and articulation of the possibilities of an IS, the requirements

are the result of the interaction between the analyst and the user (Johri, 2010). The software development process involves complex problem solving that is based on previous experience, the team members have specific individual's expertise that is embodied by the conceptual understandings and the cognitive skills of the team (Ryan & O'Connor, 2009). Business users share their explicit knowledge, the knowledge of their procedures and processes that is easy to articulate. The knowledge that business users do not explain or are unable to articulate, tacit knowledge needs to be recognised and identified as Polanyi says, "We know more than we can tell" (Johri, 2010).

Bloodgood and Salisbury (2001) state that IT can be a mechanism used to catalogue individuals that hold critical knowledge. Knowledge can be communicated in socialisation activities that will allow the transfer of knowledge. Requirements elicitation can be deemed the most important step in the ISD process, it is during this process that analysts identify potential users of an IS and their requirements (Vitharana, Jain & Zahedi, 2012).

The industrial economy has transitioned into a knowledge economy, software development is a knowledge-intensive process, people cooperate and communicate to create and share knowledge. Knowledge engineering should be integrated into the development of information (Qumer & Henderson-Sellers, 2008; Treude & Storey, 2011).

3.4.1 The requirements elicitation process

The composition of the teams in an ISD project should be cross functional. Cross functional teams promote creativity and innovation, they consist of members that come from different parts of the organisation that contain diverse knowledge. It is essential that both technical and domain knowledge are considered when IS are developed, as this is important for the successful design and implementation of IS (Tesch, Sobol, Klein & Jiang, 2009).

A requirement is the essential attributes or characteristics that a system or element of a system has. Two kinds of requirements must be developed for systems and hardware

entities - performance requirements that will define what the system should do, and design constraints, a boundary condition that the designer must adhere to while satisfying the performance requirement (Grady, 2014). Requirements are acquired by documenting the interest and expectations of the stakeholders and providing this document to designers, who will focus on the content of the requirements (Mattmann, Gramlich & Kloberdanz, 2016).

The requirements elicitation process can be divided into five activities according to (Zowghi & Coulin, 2005): (1) Understanding the domain of the application; (2) Identifying the sources of requirement; (3) Analysis of the stakeholders that will use the system and is able to provide input (4) Selecting the techniques, approaches, and tools to use; (5) Eliciting the requirements from stakeholders and other sources. The International Institute of Business Analysis IIBA (2009) identifies the following tasks to be conducted by the business analyst during requirements elicitation: (1) Prepare for elicitation by outlining the desired outcomes to be achieved by the activity; (2) Conduct elicitations to extract and identify any information that might be relevant to the process; (3) Confirm elicitation results to ensure the information that was gathered during the elicitation session was accurate and consistent with the needs of users; (4) Communicate information to ensure the stakeholders understand what was captured; (5) Manage stakeholder collaboration to ensure all stakeholders work towards a common goal.

Hickey and Davis (2004) define a general model of elicitation that assists with the selection of a technique that should be used during requirements elicitation, this model is depicted in Figure 4: Elicitation Activities.

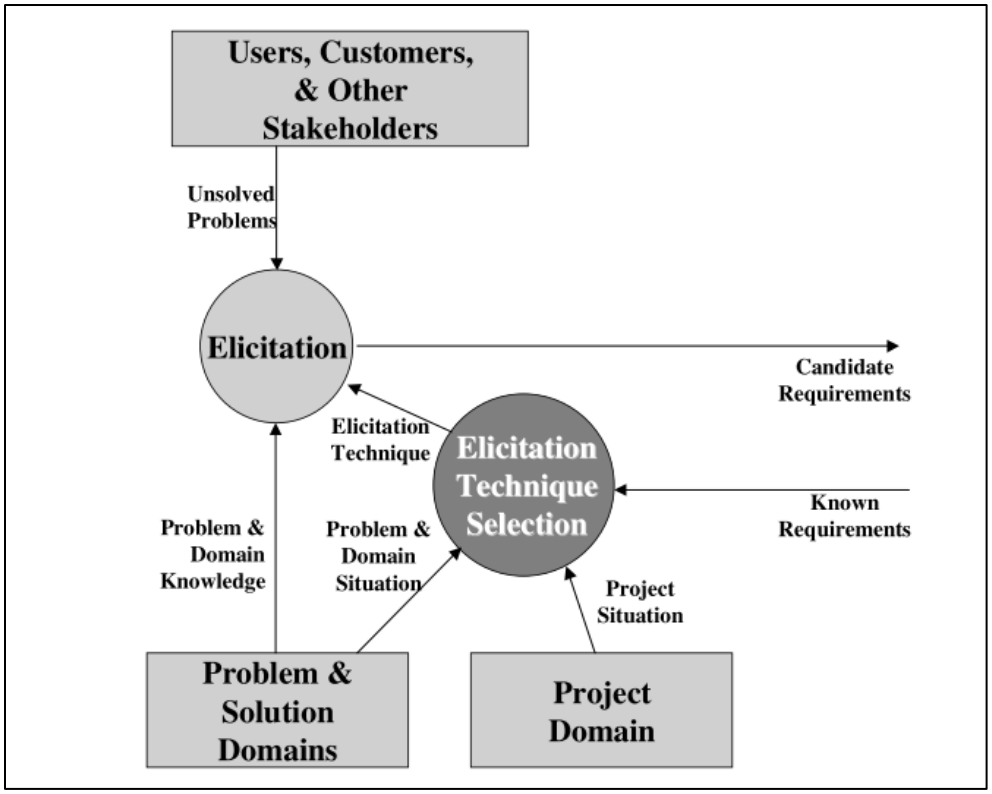

Figure 4: Elicitation Activities (Hickey & Davis, 2004)

The model presented in Figure 4 represents a generalisation of elicitation techniques and enables an analyst to understand the requirements elicitation process better and will assist in identifying the factors that should be considered when selecting techniques.
The elicitation technique selection is guided and driven by the problem, a solution, the project domain characteristics, as well as the state of requirements. It is important to know the type of requirements to identify the best technique.

3.4.2 Techniques in elicitation of requirements

The IIBA has established the business analysis Book of Knowledge (BABOK guide), this is a matured and widely accepted standard used by business analysts (Mathiesen, Bandara, Delavari, Harmon & Brennan, 2011). The guide provides many techniques that can be used during requirements elicitation. This elicitation methodology or a technique is used to gather requirements and to assist analysts in understanding the user's needs,

more than one technique can be used in different conditions. (Hickey & Davis, 2003b) further entertain the idea, stating that the analyst selects a certain technique for any combinations of these four reasons: (1) the analyst is only familiar with that technique, (2) it is the analysts' favorite technique, (3) the analyst is following an explicit methodology that prescribes a technique, (4) the analyst understands intuitively what technique to do in the situation.

Business analysis combines the analysis of customer requirements, the questioning of existing processes and potential processes, and the structuring and advice of change and development; it also deals with managing stakeholder relationship and knowledge transfer in an organisation (Bertschi, 2009).

BABOK IIBA (2009) identifies the following techniques as a guide to assist the analyst in gathering requirements: brainstorming, data mining, benchmarking and market analysis, business rules analysis, collaborative games concept modelling, data mining, data modelling, document analysis, focus groups, interface analysis, interviews, mind mapping, observation, process analysis, process modelling, prototyping, survey or questionnaire, and workshops. A discussion of these techniques follows.

Brainstorming

Brainstorming is a group method that is used to develop ideas as well as explore a number of considerations to a phenomenon or problem (Vásquez-Bravo *et al.*, 2014), each participant may develop their train of thought and is able to expand on other individuals' input, thus forming new, innovative ideas (Liou, 1992). During brainstorming, participants engage in informal discussions to rapidly generate as many ideas as possible, without focusing on one idea and allowing independent thinking and expression to discover new and innovative solutions (Zowghi & Coulin, 2005). It can elicit unconventional solutions and provides a group method for the elicitation of a variety of suggestions (Davis, 1982).

Questionnaires

Questionnaires are used to gather information. Participants complete a questionnaire which is useful to discover attributes, uncertainty factors and specific objects in a domain (Liou, 1992). This technique is an inquiry technique; information is collected through several codified questions that have been prepared by the person requesting the information. The questionnaire can be delivered on paper or in digital format (Wellsandt *et al.*, 2014).

Observation

During observation, an expert is observed in a real-life problem or day-to-day operations; this indicates how he or she reaches a decision or makes a judgement (Liou, 1992). One can either take notes and try to follow the thinking process of the expert or two, videotape the experts to review the process at a later stage (Wellsandt *et al.*, 2014).

Focus Groups

Focus groups involve the elicitation of ideas and opinions for new products or to explore new product concepts (Liou, 1992). The interview process consists of three stages and is performed by a moderator. The stages are as follows: (1) Establish a relationship, structure the rules of engagement and establish objectives; (2) Make a contentious effort to provoke intense discussions in the affected areas; (3) Summarise the groups input to form an agreement with the focus group.

Interviews

Interviewing is one of the most established techniques to elicit requirement from users, the purpose of an interview is effective communication, it can be used to repeatedly probe the user to assist in issue clarification (Agarwal & Tanniru, 1990). An interview is a face-to-face engagement and is less formal than questionnaires; it allows requirements

to be covert. The interviewer should prepare questions (open or closed) and the course of the interview can be influenced by both parties, the interviewer and the interviewee (Wellsandt *et al.*, 2014).

Data Mining

Data mining can be defined as algorithms designed to analyse data or the extraction of patterns in specific categories from data sources (Kurgan & Musilek, 2006). It is also known as knowledge extraction, data pattern processing or date archeology.

Business Rules Analysis

Business rules are rules or explicit statements that assert how a business operates, how it is structured and regulates its behaviour. It is an important asset in IS (Kovacic, 2004). It can be used to represent user requirements as well as the condition in which the system should conform, changes in business rules have an impact on software processes and business processes and this has an effect on how subject matter goes about in their daily matters (Gottesdiener, 1997; Wan-Kadir & Loucopoulos, 2004).

Collaborative Games

There have been studies that suggest techniques that foster creativity are effective methods that can be used to improve the quality of requirements (Kauppinen, Savolainen & Mannisto, 2007). Playing games enhances creativity and allow users to provide innovative ideas about the software to be developed, it is a way of practicing teamwork and a new way of thinking about getting and transmitting knowledge (Ghanbari *et al.*, 2015; Maiden & Robertson, 2005).

Concept Modelling

Concept modelling is a representation or an abstract of the real IS, it reflects the knowledge about the application rather than the implementation of the IS (Fayoumi & Loucopoulos, 2016). It is a form of simplification that focuses only on the concepts of the user as they perceive the system.

Document analysis

Software information is documented to facilitate knowledge and communication amongst stakeholders, this documentation is used locate information and achieve traceability amongst different entities (Kurgan & Musilek, 2006). The documentation is valuable as it is based on previous decisions made and can be used as a reference as a trusted and easily accessible source of information that can be analysed to obtain required information (Parnas, 2009).

Document analysis, as with any method, has advantages and disadvantages. Document analysis is an effective way of gathering data as documents are practical to manage. Documents are a reliable source of data and easily accessible (Bowen, 2009). Obtaining existing documentation is cost efficient and not as time consuming as to look for your own documents. Documents are "stable" data, can be accessed and reviewed multiple times and remain unchanged and unaffected by the research process (Bowen, 2009:31). Access to documents in the public domain is freely available. These are the advantages. The data (contained in documents) have already been gathered; what remains is for the content and quality of the documents to be evaluated.

Disadvantages include that documentation is sometimes not retrievable, or it could be an overwhelming task to locate documents. There is a possibility that documents do not contain sufficient detail, as documents are produced to serve a certain purpose which may not be what the researcher is looking for. The document available for analysis is aligned with corporate policies and procedures and might not necessarily advance the researcher's objectives (Bowen, 2009).

Interface analysis

An interface is a connection between system components IIBA (2009), it is the place at which independent systems meet and act or communicate with each other (Mandel, 2002). There are different interfaces, user interfaces that consist of input and output devices as well as the information users interact act with on their screen.

Mind mapping

Mind maps can be used as creative research when gathering requirements, it presents a way of the thinking process in a visually stimulating form, examples include mental maps, arrow graphs, conceptual maps or communication diagrams (Bystrova & Larionova, 2015).

Process analysis

The processes in an organisation describe the workflow and the transactions involved in the enterprise, the processes are modelled, redesigned or documented and can be enabled by technological support that will improve the human activities. The document can be analysed to understands the processes and the activities that take place during these processes (Tbaishat & Tbaishat, 2017).

Process analysis focusses on business processes, business processes remain relatively constant and can be a good base when conducting requirements elicitation (Davis, 1982)

Process modelling

Process modelling assists in understanding the organisation's work, providing a holistic and comprehensive process in detail and uses technology to support the human activities. It is used to achieve the required visibility for existing processes and sketch future scenarios that will improve business processes (Rosemann, 2006). Process Modelling involves the creation of processing steps followed by practitioners when executing their tasks, it too provides a road map and a common framework (Kurgan & Musilek, 2006).

Prototyping

Prototyping is an experimental activity to gather as much information as possible of the proposed IS (Luckham, Kenney, Augustin, Vera, Bryan & Mann, 1995).

3.4.3 The role of the analyst in the elicitation process

The unstructured knowledge in people's heads can be of importance to an organisation, extracting the knowledge to put into a repository can be difficult, one should rather look at the facilitation of tacit knowledge (Davenport, De Long & Beers, 1997). The activities in the development of requirements elicitation will consist of people from at least two business areas: Firstly, the business (users and other stakeholders) and secondly, the IT business area (analysts and project managers) (Chikh, 2011). Tacit skills have been acquired explicitly and it became tacit through time, this is because people don't realise what they were doing or questioned what they were doing. These skills cannot be expressed in normal conversation but can be articulated differently by storytelling (Al-Qdah & Salim, 2013). The requirements specification document contains the collective memory for the design team that is used to develop an IS, the material scribbled by individuals, the notes on the blackboard and the thoughts and impressions of the individual team members are not captured in this document (Walz, Elam & Curtis, 1993).

There are a number of activities conducted by the analyst during the requirements process, this involves gathering detailed information, defining the requirements, prioritising requirements, development of user interface dialogues and the evaluation of requirements with users (Satzinger *et al.*, 2011). Requirements elicitation focuses on the structure and specific methods on how requirements should be gathered, the emphasis is on formal approaches, little attention is given to the cognitive capabilities of the system analyst, without whom techniques are irrelevant (Pitts & Browne, 2004).

3.4.4 Knowledge capturing during requirements elicitation

The coding and transmission of knowledge is not a new concept in organisations, training and employee development programs, policies, procedures, reports and manuals have insured that knowledge is transmitted (Alavi & Leidner, 1999). Knowledge is personalised, and it must be communicated in such a way that it is interpretable and accessible to the other person, it is of little value if it is processed in an individual mind and not extracted

to be useful (Alavi & Leidner, 1999). Organisations should identify the critical knowledge as not all knowledge is critical. In other words, organisations need to identify which knowledge needs to be retained and what is at risk of being lost (Aggestam *et al.*, 2014).

Different techniques have been identified to conduct the requirements elicitation; this requires interaction, collaboration and discussions with different stakeholders, once the process has been completed, the findings need to be documented (Serna, Bachiller & Serna, 2017). The development of software means working with knowledge, this process requires collaboration and communication, this knowledge comes from different sources, i.e. business people's experiences, technology, and business rules. Therefore, there needs to be a conscientious effort to discover knowledge and give it meaning in a common language that can be understood by everyone involved (Serna *et al.*, 2017).

To understand the meaning of knowledge in the requirements elicitation process, (Serna *et al.*, 2017) identified the following KM models: (*1) Wiig Knowledge Management Cycle* - The purpose of the model is to facilitate the creation of knowledge, the team must have the experience to approach the different phases in the cycle and have relevant knowledge of the problem at hand; *(2) ICT Spiral for Knowledge Management Processes* - This model uses ICT to assist in knowledge management, explicit knowledge is gathered from the different sources and it is interiorised and made useful-*; (3) Integrated Knowledge Management Systems (IKMS)* - In this model, access to the data- information-exchange is provided which assists in the elicitation and analysis of requirements, it also facilitates access to relevant information that will allow the understanding of a problem*; (4) Knowledge Management Software Process Improvement* - This theoretical relational model looks at a problem and facilitates the discovery and it what issues of knowledge that people had about the problem*; (5) Customer Knowledge Management* - This can be defined as a continuous process where knowledge is generated, distributed and utilised between the relevant parties (Serna *et al.*, 2017). The goal of this model is to manage and explore all of the knowledge that is possessed to understand the problem.

(Serna *et al.*, 2017) found that the process of requirements elicitation cannot be standardised, and there is a need to have a model that is more innovative and provide a way to create new knowledge.

Software requirements cannot be elicited without taking a system perspective, software forms part of the larger system, when requirements are elicited the whole system should be taken into consideration as the needs of stakeholders are different (Boegh, 2008). The software requirements document is a product of requirements elicitations, this document describes the proposed software system (Aggestam *et al.*, 2014).

The creation and development of a Software Requirements Specification (SRS) document is a process that requires insight, the key elements contained in the document needs to be accurate and reusable as this will be distributed in the organisation to the relevant stakeholders. The key elements are the software requirements that have been elicited analysed, specified, verified, validated and documented (Robert A. Elliott & Allen, 2013). This official document is used to inform the system developers what they should implement and provides an understanding of what the system is supposed to do (Chikh, 2011).

To ensure that the requirements are documented properly, the IEEE Standard 830-1998 for a software specification can be followed, this is a guideline that can be used for the format and creation of an SRS (Robert A. Elliott & Allen, 2013). This is a generic standard that describes the recommended approaches for the SRS and the content and qualities of a good SRS (Chikh, 2011).

The guidelines and standards provided by the IEEE Standard 830-1998 provides a basic overall outline of what should be contained in the SRS and Table 5 below lists the sections that could be included in an SRS, as noted by (Kirner & Abib, 1997).

Table 4: Content of a Software Requirements Specification

Section	Content of Section
Introduction	This includes the definition of the purpose of the SRS; what the scope of the product is definitions contained in the document acronyms abbreviations the references and overview of the rest of the SRS
General description	This is the definition of the product perspective; the product user characteristics; general constraints assumptions and dependencies
Specific requirements.	This is the definition of all the specific requirements that will be needed for the application
Functional requirements	This is each specific requirement in terms of the inputs the processing and the outputs
External interface requirements	This is a definition of the user, hardware, software and communication interfaces
Performance requirements	This is the definition of all the performance requirements of the proposed system
Design constraints	This is the definition of the compliance of the system that needs to be standard as well as hardware limitations
Attributes	This is the definition of the non-functional requirements such as availability security safety transportability
Other Requirements	This is the definition of the database requirements, Operational Requirements, etc.

3.5 Summary

In this chapter, the researcher looked at the SDLC and where in this process requirements elicitation is key. It was found that the analysis phase takes place when requirements elicitation is executed and this is where knowledge can be captured.

The conclusion is that elicitation is found in the analysis phase of the SDLC. Throughout the chapter, there was a focus on the requirements elicitation process, the detail activities were discussed, and the researcher looked at different techniques that could be used by the analyst, the content of the SRS that is developed after the requirements is completed was also reviewed. The role of the analyst was also investigated to understand what it is the analyst needs to do during the elicitation process.

Chapter 4 Research Methodology and Design

4.1 Introduction

This chapter provides background to the objectives and purpose of the research activity. It focuses on mixed method research in IS and describes the research process used in this study. A detailed study of the literature was conducted to establish a view of requirements analysis. A questionnaire was then used as the data collection instrument to understand requirements analysis in a HRO; therefore, analysis of the questionnaire will be discussed. The last section will look at the ethical issues, as well as the limitations of the research.

4.2 Research Process

Research refers to the search for knowledge, it can also be defined as a scientific and systematic search for relevant information on a certain topic (Kothari, 2004). The purpose of the dissertation is to understand the role of knowledge capturing during the requirements elicitation process in an HRO.

Information research will continuously diversify. Since the inception of the field of IS in the 1960's, a wide range of issues has been addressed with IS research. This is evident by the variety of topics that reference IS research and that share a common interest (Robey, 1996). To explain the research process for the research study, Saunders *et al.* (2009) developed the research onion, this is a symbol for the research process, and it consists of different layers: research philosophy, research approach, research strategy, and time line and data collection. This definition is illustrated in Figure 5.

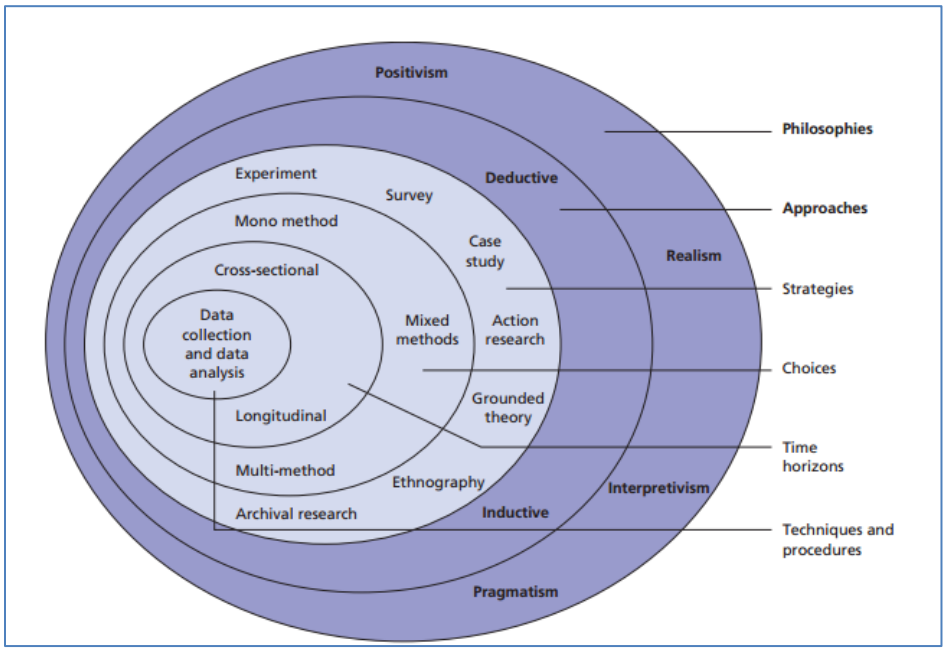

Figure 5: Research Onion (Saunders *et al.*, 2009)

This layered approach will form the base of the researcher's approach. This chapter is a presentation of the research design (case study) and it includes the rationale for following the research approach (mixed method) and the data collection (questionnaire).

4.3 Outline of Chapter 4

Table 5 below provides an outline of Chapter 4; Information Research will be discussed to explain the relevance of the study and the field of Information Systems Research (ISR). The philosophical perspectives will follow this, where the researcher explains the philosophical perspective. The research approach, strategy, methodology, and design is discussed followed by the data collection, and the ethics and anonymity of the study.

Table 5: Outline of Chapter 4

Outline of Chapter 4			
Section	**Description**	**Sub-section**	**Sub-section description**
4.1	Introduction		
4.2	Research Process		

4.3	Outline of Chapter 4		
4.4	Information Systems Research		
4.5	Philosophical Perspectives		
4.6	Research Approach	4.6.1	Qualitative, Quantitative and Mixed Methods Research Approach
4.7	Research Strategy	4.7.1	Research Methods
4.8	Research Methodology and Design	4.8.1	The Research Questions
		4.8.2	Research Methodology
4.9	Data Collection	4.9.1	Data Collection Instrument
		4.9.2	Questionnaire Distribution
		4.9.3	Questionnaire data analysis
		4.9.4	Reliability and Validity
		4.9.5	Response Rate
4.10	Ethics and Anonymity	4.10.1	Permission
		4.10.2	Confidentiality and Privacy
		4.10.3	Voluntary participation and informed consent
4.11	Summary		

4.4 Information Systems Research

The goal of IS research is two-fold: it can improve the practice of IS or it can contribute to the field of IS to produce IS knowledge and the development of the discipline (Cavaye, 1996; Loebbecke, Huyskens & Berthod, 2007).

IS researchers start with the premise that an IS is an instance of a socio-technical system, but the researcher looks beyond the organisation and focuses on the information phenomena that deserved its own focus (Andrade, 2007; Orlikowski & Iacono, 2001).

Orlikowski and Iacono (2001) state that information research has not addressed its core subject matter, which is the IT artefacts. There has been a tendency to take IT for granted in IS research, and there is a need to use the interdisciplinary of IT artefacts that will inform further studies. IT artifacts are constructed, designed and used by people and is therefore shaped by the values, assumptions and interests of the various community of developers. This tendency of taking IT artefacts for granted in IS studies has limited the ability of researchers to understand the critical implications IT has for groups, organisations and individuals. The IS research community under-investigates phenomena that relate to IT-based systems and over investigated phenomena that has a distant relation with IT-based systems, this causes the nature of the IS discipline to be vague and obstructs the reinforcing of a central identity in the IS discipline (Benbasat & Zmud, 2003).

In a quest to establish the importance of IS research, Loebbecke *et al.* (2007) investigated the production of IS knowledge and the development of the IS discipline by conducting citation analysis on IS journals published between 1996 and 2005. They found that most of the IS papers in IS do not produce further knowledge, this could suggest that IS research is not as important to other researchers, and according to the literature, the research lacks relevance and importance to fellow researchers.

The elicitation of requirements plays an integral role in the development of IS, which makes a direct contribution to the IS discipline as it looks at the knowledge capturing artefact and the role that it performs.

4.5 Philosophical Perspectives

Research philosophy deals with the first layer of the research onion, it is the development of knowledge as well as the nature of that knowledge and it underpins the researcher's view of the world (Saunders *et al.*, 2009).

There are two thought processes philosophy can be approached with, namely: ontology and epistemology (Saunders *et al.*, 2009). Ontology deals with "the nature of being", the focus is on what reality is and what the categories of reality are (Creswell, 2013; Neuman, 2014). Epistemology is concerned with the creation of knowledge; the focus is on how we know what we know or "what are the most valid ways to reach truth?" (Neuman, 2014:95).

The epistemological perspective requires researchers to get close to the participants that are being studied, the evidence is based on subjective views as this is how the knowledge becomes known and what people experience (Neuman, 2014).

According to Hirschheim (1985:1), in a paper to address the epistemology of IS, epistemology refers to "our theory of knowledge" (Hirschheim, 1985:1). How we acquire knowledge consists of two basic points: What is knowledge? And how is valid knowledge obtained? Hirschheim suggests that IS epistemology are social rather than technical systems as they rely a great deal on social science, and epistemology is the theory of knowledge. Social science is the science of people or collections of people (Bhattacherjee, 2012; Loebbecke *et al.*, 2007).

This dissertation requires an approach that encapsulates the dynamics of this phenomena and this is entrenched in a mixed methods epistemology. This is to ensure that human behaviour and experiences during this process are encapsulated in order to provide an objective dissertation by using data collected from the participants in combination with a literature study of the phenomenon. This research is based on a mixed methods approach that will be discussed in detail in the following section.

4.6 Research Approach

The second layer of the onion refers to the research approach that the researcher will follow. A research approach is the plans and the procedures that describe the steps of broad assumptions to the method of data collection, analysis as interpretation (Creswell, 2014).

4.6.1 Qualitative, Quantitative and Mixed Method Research Approach

Creswell (2014) describes three research approaches. Firstly, *qualitative research*, an approach that is used to explore and understand the meaning of individuals or groups that is part of a social problem, the data collected is in the participants setting. Secondly, quantitative *research* is an approach that is used for testing theories and to investigate the relationship among different variables, these variables produce numbered data that can be measured and analysed using statistical methods. Lastly, *mixed method*, which combines or integrates qualitative and quantitative research.

Quantitative research methods originated from the natural sciences and was used to study natural phenomena, and qualitative research methods originated from the social sciences to enable researchers to study cultural phenomena (Myers, 1997). Qualitative research uses methods such as case studies, interviews, observation as well as textual analysis, and this provides insights into what people have said as well as their thoughts (Myers, 1997). Mixed methods use qualitative and quantitative data in a single or multiphase study to answer a set of questions (Hesse-Biber, 2010).

Creswell (2014) distinguishes between qualitative research and qualitative research in respects of using words (qualitative) instead of numbers (quantitative) or the approaches can be differentiated using close-ended questions (qualitative) instead of open-ended questions (qualitative).

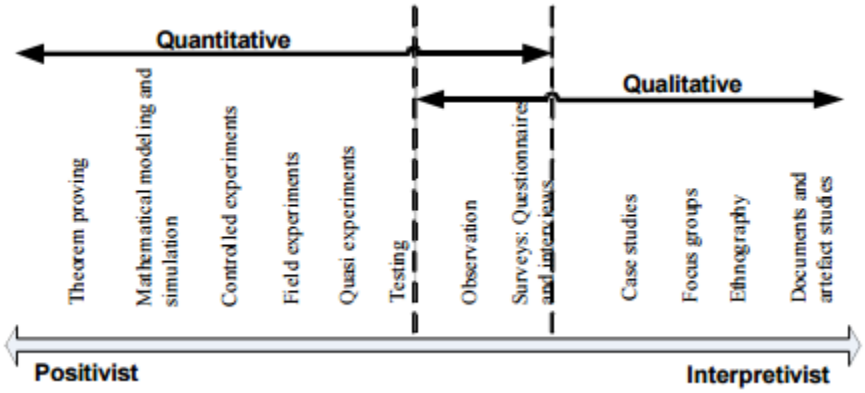

Figure 6: Research Method/Strategies (De Villiers, 2005)

The illustration in Figure 6: Research Method/Strategies shows the leading research methods (De Villiers, 2005). It shows there is an overlap of the quantitative and qualitative approaches which indicates that the methods are not mutually exclusive. Qualitative research is associated with interpretative studies (Conboy, Fitzgerald & Mathiassen, 2012). Interpretive researchers work with the assumption that reality can only be accessed through social constructions and the philosophical base is hermeneutics and phenomenology (Myers, 1997). Research methods refer to the type of research and techniques that might be used in the collection of empirical evidence. There are two types of collection methods namely: Nomothetic, or quantitative (numerical) data, and qualitative (verbal) data (Cavaye, 1996; Jabar, Sidi, Selamat, Ghani & Ibrahim, 2009). Nomothetic methods draw solely on procedures that are used in the exact sciences, and it alludes to general laws that apply to the phenomenon (Benbasat, Goldstein & Mead, 1987).

There has been a growth in the interest of qualitative research methods; these methods focus on a social phenomenon (Darke, Shanks & Broadbent, 1998). This approach requires that the researcher follow a qualitative approach which is designed to understand people and ensure that human decisions and actions are understood in context (Myers, 2009). Hammersley (2012) defines qualitative research as a form of social inquiry that adopts a flexible and "data driven research design" (Hammersley, 2012:12). In

other words, to use unstructured data to emphasise its subjectivity in the research process that allows the studying of natural occurring cases using verbal information instead of statistics to analyse the data.

Three major methodological philosophies have formed qualitative research, these are: interpretive, positivist, and critical (Hammersley, 2012; Myers, 1997). Figure 7: Underlying Research Assumptions illustrates that the method chosen by the researcher is independent of the underlying philosophical position that was adopted.

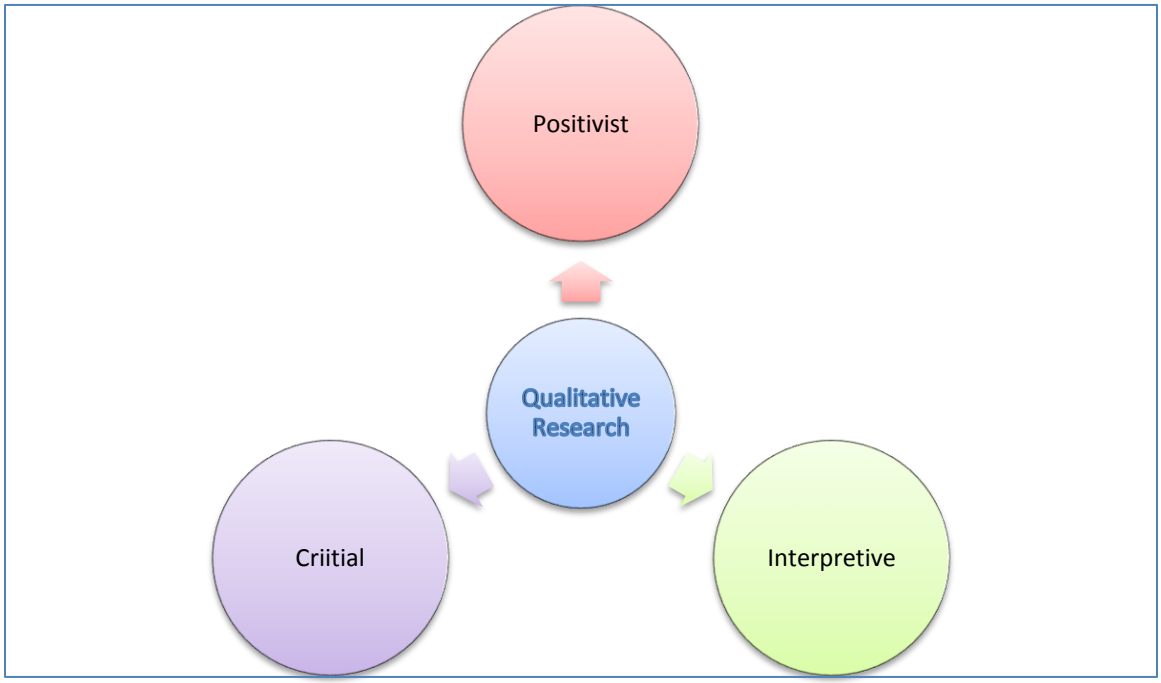

Figure 7: Underlying Research Assumptions (Myers, 1997)

Positivist studies serve primarily to test theories to understand the phenomena at hand, and it is premised on the existence of prior fixed relationships. *Interpretive* studies attempt to explore the phenomena of interest in its natural setting, without prior knowledge of it; and *Critical* studies aim to expose underlying structural problems and to critique the status quo (Orlikowski & Baroudi, 1991).

Myers (1997) describes these three paradigms as follows: Positivist approach as a study that makes a general assumption that reality is objectively given and it can be described by measurable properties, independent from the observer (researcher) and his or her instruments (Myers, 1997:38,39,43). With the interpretive approach, access to reality is only through social constructions such as shared meaning and language; and the critical approach assumes that social reality is historically constituted and produced and reproduced by people. Researchers who follow the critical approach assumes that social reality has been created historically, and that people produce and reproduce it, people might try to change their social and economic circumstances but is constrained by the cultural, political and social factors.

Researchers conducting interpretive studies attempt to understand the phenomena through accessing the meaning that the participants have assigned to them, there is an assumption that people create their own inter-subjective and subjective meanings through the interactions of the world around them Orlikowski and Baroudi (1991).

The researcher adopted a mixed method approach, qualitative data were collected from the literature study and graphs were created based on the data collected by the questionnaire (quantitative).

In their study on how to *conduct and evaluate interpretive field studies in Information Systems*, (Klein & Myers, 1999) state that IS research is interpretative if it assumed that the knowledge that we gain from our reality is retrieved only through the social constructions such as shared meaning, documentation, language and other artifacts. They also state that interpretive research does not predefine dependent and independent variables, but the focus is on how human beings make sense and act in certain situations.

It is difficult to capture social reality in formal propositions and to quantify it and to subject it to experimental controls, this is said to be reasons why social science has not reached the maturity of natural science (Lee, 1991). The interpretative approach to organisation

research is of meaning that methods of social science are inadequate to the study of social reality. The social scientist must interpret the empirical reality in terms of what it means to people, and the data and facts that are collected should not only describe the objective and the observable human behaviour but the subjective meaning that this behaviour has for humans themselves. Ponelis (2015) characterises interpretive research as "a need to understand the world as it is from a subjective point of view and seeks an explanation within the frame of reference of the participant rather than the objective observer of the action" (Ponelis, 2015:538).

As explained in Chapter 1, the rationale for this study came about when the researcher was conducting an elicitation session. The researcher aims to understand how knowledge can be captured to ensure that the information shared does not get lost in the process. Interpretative research will allow the researcher to understand this phenomenon within its context. Collecting and analysing qualitative data can be time consuming as a vast volume of data can be collected, this could inhibit analysis but does not discount the ability to draw conclusions from the data collected (Cavaye, 1996). Four research methods are used by IS researchers, these are: case study research, action research, ethnography, and grounded theory (Jabar *et al.*, 2009). These methods are further explored in the sections below.

4.7 Research Strategy

In this section, the next three layers of the research onion – strategy, choices, and timelines – are discussed.

A research strategy is informed by the research questions and the research objectives (Saunders *et al.*, 2009). The purpose of this dissertation is to understand the role of knowledge capturing during the requirements elicitation process. Yin (1994) suggests that if the research question wants to explore "how" and the researcher does not have control of behavioural events, a case study can be used as a research strategy.

To improve effectiveness and efficiency in an organisation, IS are implemented, it is necessary for researchers in the IT field to promote knowledge that will assist in the productive application of information technology and to develop the use of IT for the organisation (Von Alan, March, Park & Ram, 2004).

More consideration was given to the use of case studies in IS research for the following reasons: Firstly, the object of the IS discipline is research in IS in the organisation, the focus is on the organisational rather than the technical issues. Secondly, the access and reporting on real-life IT experiences allow both practice and academia to keep up with the changes in organisations as well as in the IT world. Third, a key characteristic of case research is the holistic investigation of the organisation; this involves the understanding of the omnipresent and complex interaction among technologies, people, and the organisations. Fourth, a comprehensive case investigation provides new ideas, new lines of reasoning and can identify challenges and opportunities faced by the manager and IT people. Fifth, not only can case research be used for exploration and hypothesis generation, but it can also be used for testing hypotheses and providing explanations (Dubé & Paré, 2003).

The researcher investigated published research to understand the role of knowledge capturing during the requirements elicitation process of IS development. The objective of the research is to determine the how knowledge can be captured effectively during the elicitation of requirements in an HRO and to identify knowledge artefacts during the requirements process to show what constitutes effective knowledge capturing.

4.7.1 Research Methods

In the next sections four research methods are described in more detail, namely: case study research, action research, ethnographic research and grounded theory study research.

4.7.1.1 Case Study Research

Benbasat *et al.* (1987) provides three reasons why case study research is a feasible IS strategy: One, IS can be studied in a natural setting, this will allow learning from the case and provide the ability to generate theories from practice; two, case study allows the researcher to ask "why" and "how" questions and enables the understanding and the nature and complexity in the processes that are taking place and: three, it is an appropriate way to research an area where other studies have not been introduced.

The drawback to the case study is that there is subjectivity in the data collection processes and there are difficulties in the generalisation of the results (Cavaye, 1996; Darke *et al.*, 1998). Lee (1989) identifies the following four challenges for case studies: (1) How to make controlled observations in testing for relationships when you are unable to control variables as a case study in its nature precludes this; (2) The ability to make controlled deductions in the absence of methodological convenience of working with stated propositions, the case study researcher has to manage with qualitative data and verbally stated propositions; (3) The case study researcher is unlikely to observe the same set of events, thus no allowance for replicability; and (4) There is no allowance for generalisability, making the study vulnerable to charges that the finding will not be able to be extended to other circumstances.

Case studies can be useful: (1) To aid in the interpretation of quantitative findings; (2) As a means of triangulation to test the case sample; (3) To develop relationships with organisations; (4) As a test of the contextual reference and; (5) As an addition in the identification of after the fact models (Gable, 1994). A research strategy is informed by the research questions and the research objectives (Saunders *et al.*, 2009). The purpose

of this dissertation is to understand how knowledge can be captured effectively in the requirements elicitation process.

Case studies can be single or multi-case studies. A single case study allows researchers to investigate a single phenomenon in detail and provide a detailed description and understanding. A multi-case study allows cross analysis and comparison of different case studies, it could be used to predict results, but it can also be used to produce contrasting results (Darke *et al.*, 1998).

More consideration was given to use case studies in IS research for the following reasons: Firstly, the object of the IS discipline is research in IS in the organisation, the focus is on the organisational rather than the technical issues. Secondly, the access and reporting on real-life IT experiences allow both practice and academia to keep up with the changes in organisations as well as in the IT world. Third, a key characteristic of case research is the holistic investigation of the organisation; this involves the understanding of the omnipresent and complex interaction among technologies, people, and the organisations. Fourth, a comprehensive case investigation provides new ideas, new lines of reasoning and can identify challenges and opportunities faced by the manager and IT people. Fifth, not only can case research be used for exploration and hypothesis generation, but it can also be used for testing hypotheses and providing explanations (Dubé & Paré, 2003).

The focus of this dissertation is on an organisation. Case studies capture the reality in detail, allowing for the understanding of the cultural, social, and political factors that might have an impact on the dissertation. Case studies enable detailed inquiry of a subject used to evaluate the legitimacy of the problem and allows researchers to gather realistic data of the phenomenon being investigated in social and behavioural scientific research (Bhattacherjee, 2012). Case study research uses empirical evidence from real people in their everyday lives and allows the asking of “how” and “why” questions (Myers, 1997). This could assist in identifying and understanding the interrelatedness of KM and ISD, as the researcher would be able to understand holistically how the different subjects are

used within the entire organisation. Conducting case study research allows the researcher to understand the behavioural patterns of the studies phenomenon and trace the relationship with other factors (Kothari, 2004).

4.7.1.2 Action Research

The action research method is a combination of observation and participation where the researcher does not define the research problem, rather, the problem is defined by the situation, there is no control over the variables and the intention is to record and observe (Cavaye, 1996).

Action research is a two-stage process. The first is a diagnostic stage that involves a collaborative analysis of the social situation by the researcher and the subjects of the research. A hypothesis is formulated that concerns the nature of the research domain. The second is the therapeutic stage that involves collaborative change experiments. Changes are introduced, and the effects are studied (Baskerville & Wood-Harper, 2016). Action research attempts to link theory and practice, doing and thinking, and the gaining of knowledge is an active process. This method is applied to develop a solution that is of practical value to people with whom the researcher interacts, and to develop theoretical knowledge that will be of use to the research community.

4.7.1.3 Ethnographic Research

This research method interprets the data through the eyes of the participants of the phenomenon, it seeks to understand the meaning of the phenomenon at hand (Cavaye, 1996). Ethnographers are required to spend a significant time in the field to place the phenomenon in its social and cultural context and to immerse themselves in the study at hand to get a closer feel for the phenomenon with an emphasis on culture (Jabar *et al.*, 2009; Myers, 1999; Whitehead, 2005). The primary data collection is conducted through field work, and the ethnographer becomes familiar with the spatial dimensions of the research setting and the socio cultural dynamics, which might change at any time (Whitehead, 2005).

This personalist process makes reliability of the studies difficult, as the presentations of the findings may be affected by traditions and ideologies in anthropology. This also influences the validity of the studies, as the very nature of ethnographic studies can obstruct or reduce the comparability and translatability of the study (LeCompte & Goetz, 1982).

4.7.1.4 Grounded Theory Study Research

Grounded theory research was first introduced in 1967, and the theory is designed to provide a thorough theoretical explanation of the social phenomena that is being studied. This theory should explain as well as describe and provide implicitly a degree of predictability but within the conditions that were illustrated (Corbin & Strauss, 1990). Grounded theory is a research method that seeks to develop theory that is grounded in data systematically gathered and analysed (Jabar *et al.*, 2009). De Villiers (2005) states that grounded theory provides a conceptual grasp of substantive issues, it evolves and is modified to fit as the finding occurs and new data emerges. It also accounts for the variation in domain behaviour as it defines properties, categories and relationships.

4.8 Research Methodology and Design

The objective of the research is finding answers to questions by applying scientific procedures and to discover the truth that was hidden, and that which has not been discovered yet. (Kothari, 2004) theorises that research can be divided into different groups (1) to gain an understanding about a phenomenon *(exploratory or formulate research)*; (2) the representation or characteristic of a situation, group or individual *(descriptive research)*; (3) to determine systematically how frequently something occurs *(diagnostic research);* (4) “to test hypothesis of a causal relationship between variables” (Kothari, 2004:19). Researchers must collect and analyse new information or data that will enhance the body of knowledge (Ellis & Levy, 2008; Nunamaker, Chen & Purdin, 1990).

The research design is the general plan on how the research questions will be answered to establish new facts as well as information about a phenomenon (Saunders *et al.*, 2009). Research design provides social scientists with tools to test their hypotheses. There are four basic research designs that can be applied, and these are: experiments, surveys, field research, and secondary sources (Abbott & McKinney, 2013). Research design links the research questions , and the data collected to draw a conclusion and provides a conceptual framework and an action plan to for the researcher to find answers and devise a conclusion (Yin, 1994).

4.8.1 The Research Questions

In Chapter 1, the researcher defines the purpose of this study, the main research question is:

How can knowledge be captured effectively during the elicitation of system requirements in a high-reliability organisation? And its secondary questions:

- What constitutes effective capturing of knowledge?
- How do you identify knowledge artefacts during the elicitation of system requirements?

4.8.2 Research Methodology

After the research problem is identified, the researcher should identify the appropriate methods that will assist in understanding the problem. To address the process in this paper, the researcher used the research onion, the approach to use the onion is to go from the outer layer to the inner layer.

The research method for the qualitative researcher is the way of deciding how the social world will be investigated, and the researcher needs to decide how the research question will be answered and if the researcher wants to study organisations, managers or consumers (Myers, 2009). The foundation of each research method is the underlying philosophical

assumptions and the research methods that are chosen will influence the way in which data is collected by the researcher (Myers, 1997). The case study provides opportunity to ask pungent questions about a specific behaviour in the organisation and seeks to understand the problem at hand (Gable, 1994).

Case studies have been used frequently but historically, have been stereotyped as a weak research method. According to Patton and Appelbaum (2003), the use of case study by researchers is allegedly lacks precision, rigor and objectivity and they have deviated from their academic disciplines. Using theory in the early stages of an interpretive case study creates the initial theoretical framework which takes into account previous knowledge and creates what is referred to as a "sensible theoretical basis" (Walsham, 1995:76). According to Walsham (1995), this basis will inform the topics as well as the approach to the theoretical work. Human's interpretation of IS is intricate in the practice of IS as well as to the investigations conducted by IS researchers. Myers (2009) provides a few guidelines for when a research method is chosen, namely: The appropriateness of the method to the research question; the achievement of the desired results when this method is chosen; the conditions of use for the method; the limitations or the weaknesses of this method; other methods that are appropriate to the research question; why the chosen method is better than other methods, the skills required for these methods (Myers, 2009:25).

Based on these guidelines, and the research questions, the unit of analysis as identified by the researcher, case study research allows the researcher to understand the behavioural patterns of the studies phenomenon and can trace the relationship with other factors (Kothari, 2004).

In addition to the confirmation of the research method mentioned above, the researcher confirmed the selection with the research approach defined by (van der Merwe, Kotzé & Cronje, 2005). These authors provide an evaluation tool that will enable the researcher to identify what research method is suitable for the research study. The evaluation tool

identifies different research approaches and for each approach, a different characteristic is identified. Based on the research question, the appropriate characteristic is selected and the approach and characteristics that carry the most significance provide an indication to the research method.

The researcher took each research question of the dissertation and evaluated it against each approach and characteristic identified in the evaluation tool. Based on the approach and characteristics, the researcher identified if this was applicable to the research question. If this was applicable, the characteristics were identified with an "X".

The outcome of the evaluation is indicated in Table 6: Evaluation tool to identify research approach.

Table 6: Evaluation tool to identify research approach

Approach	**Characteristics**	**Research Question 1**	**Research Question 2**	**Research Question 3**
		How can knowledge be captured effectively during the elicitation of system requirements in a high-reliability organisation?	What constitutes effective capturing of knowledge?	How do you identify knowledge artefacts during the elicitation of system requirements?
Interpretive research	Mainly theoretical study		X	
	Contradictions			
	Interpretation			
Critical social role theory	Critical social			
	Social role theory			
Action research	Focus on what practitioners do	X	X	
	Explicit criteria			
	Practitioners and researchers			

	with mutual goals			
	Apply theory with goal to enhance			
Case study	Investigator has little control	X	X	
	Contemporary phenomenon with real-life context	X	X	X
	Study life cycles	X	X	X
Ethnographic research	Active participation			
	Observational data			
	Social contact with participants	X	X	X
	Extended depth study			
	Limited to one field study			
Grounded theory	Starts with a phenomena			
	Data sampling with perspective			
	Theoretical account of the general features			
	Generation of theories of process, sequence, and change pertaining to organizations, positions, and social interaction			

Based on the characteristics identified by (van der Merwe *et al.*, 2005), the research study can be characterised as a case study; this can be seen in the result of the evaluation tool.

4.9 Data Collection

The researcher's study was initiated by the collection of secondary data; this data refers to any material, journals, books, etc. that has been published to inform the phenomena (Adams, 2007). The data collected was to inform the research questions that focus on , knowledge capturing and requirement elicitations. This statistical analyses of qualitative data that was collected are also known as secondary analysis (Neuman, 2014).

According to (Hodapp, Goldman & Urbano, 2013), the utilisation of secondary data has the following advantages: Researchers save time and money by using data sources that have already been studied and published as the background work has already been done; access to a multiple research studies to inform the dissertation at hand and access to a large source of information as the material uses have been extensively reviewed and the researcher does not have to concern him or herself with the ethical issues as this has already been addressed. A disadvantage of using secondary data is that the researchers do not have control over the research sample size or the sampling that was used. Another is that researchers do not have first-hand knowledge of the research that was done.

The data collection for this dissertation is both primary and secondary data. The background knowledge that was derived from the literature study on the secondary data served as a guide to the development and identification of the research instrument which is in this case, the questionnaire, which is the primary data collection method in the study.

Primary data refers to data that was received first-hand from individuals in an organisation (Adams, 2007). Primary data "adds richness and credibility to qualitative manuscripts" (Myers, 2009:120). It represents added value as the data collected is unique to the research study. A questionnaire is an instrument that consists of a series of questions and/or statements that have been designed to gather responses, these responses can be converted into measures of the phenomenon that is being researched or investigated (Murray, 1999).

The following section will provide a description and explanation of the utilisation of a questionnaire as the data collection instrument. The researcher will explain how the population for the research was identified, how the questionnaire was designed and how validity and reliability were ensured.

4.9.1 Data Collection Instruments and Method

The researcher required an understanding of the role of knowledge capturing during the requirements elicitation process. There was a need to understand the processes from different sectors in the business and a self-administered questionnaire was utilised. A self-administered questionnaire is a questionnaire that is given or mailed to respondents, who in turn read the instructions and record their responses (Neuman, 2014). Conducting questionnaires require respondents to respond to the same set of questions in a predetermined order (Saunders *et al.*, 2009).

The utilisation of questionnaires offer several advantages, including that questionnaires are a less expensive form of data collection, the dissemination of questionnaires is quick and efficient. In addition, data errors that could be entered by respondents are avoided and analysis can be made faster as the data does not have to be collated, and researchers do not have to decipher handwriting when questionnaires are sent electronically (Hunter, 2012).

4.9.1.1 Questionnaire Sample Selection

Sampling is a technique that provides a range of methods that enables the researcher to reduce the data that's required for collection by only considering a sub group of data rather than a large group and generalise the population in the process (Neuman, 2014; Saunders *et al.*, 2009). It is important to describe how samples were selected for the questionnaire, often a random sample might be infeasible and could pose questions on the validity and representation of the sample frame (Grover, Lee & Durand, 1993).

Saunders *et al.* (2009) divide the sampling techniques into two groups: non-probability or judgmental sampling, and probability, or representative sampling. The difference between the two types of sampling is that the non-probability technique is that the chances of each case that is selected from the sample are unknown, while probability sampling is a technique where the chances of each case that is selected from the sample are known.

The researcher used the probability technique with purposeful sampling. This technique was chosen as the most appropriate method for this research as the researcher would be able to select the participants for the study.

According to (Saunders *et al.*, 2009), the process followed in representative sampling is as follows: The researcher identifies a suitable sampling frame that is based on the research questions, decides on a suitable size for the sampling, and checks that the sample is representative of the population.

The criteria identified in Table 7: Research Participant Rationale was applied to identify research participants (sampling frame). The researcher identified the participants based on the role that they play in the organisation. By applying this selection, the researcher could ensure that a varied response was received from the respondents.

Table 7: Research Participant Rationale

	Criteria	Rationale	Employee Profile
1	Technical / Systems Background	Utilise their understanding of the process of IS implementation and their knowledge of system maintenance and monitoring	This employee has a technical background of systems and systems implementation
2	Broad Understanding about the business and processes	Utilise their understanding of the of the overall context of the business	This employee requires an understanding of the broad business process, how the different departments interlink and how r

3	Involved in IS implementation	Utilise their understanding of the ISD process and their understanding and knowledge of requirements elicitation	This employee has been part of IS implementation, understands the system and the requirements process
4	Involved in sharing knowledge	Utilise their understanding of the mandate and objectives of Information and KM in the organisation.	This employee is involved in the organisation's information and KM activities

4.9.2 Questionnaire Distribution

The questionnaire was created and developed in MS Word, it was emailed to 150 email recipients identified by the researcher, and the primary data collection was performed between February and June 2017.

The researcher received responses to the questionnaire from the respondents via email and saved a copy on a computer to serve as proof and to indicate that the respondents provided informed consent to participate in the research. A total of 64 completed questionnaires were received yielding a response rate of 43%.

4.9.2.1 Format and content of questionnaire

Case study research can be used with any philosophical perspectives, whether it is positivist, interpretive or critical, usually a combination of qualitative data collection methods such as documentation, observation and interviews but it can also include quantitative data such as time series and questionnaires (Dubé & Paré, 2003).

The complete process needs to be considered when the questionnaire evaluation is conducted, there are tightly interrelated issues between time, costs and decisions (Grover *et al.*, 1993).

The questionnaire was developed to gain insight into the employees' understanding of the research questions and was divided into four sections as presented in Table 10 below.

Table 8: Sections in the questionnaire

Section Description	Questions used
Biographical Information	The purpose of this section was to gather the biographical and demographic information about each respondent as well as to document the profiles of the employees
Knowledge Management	The purpose of this section was to determine the respondents' demonstration on KM in the organisation and how it is perceived
Information System Requirements	The purpose of this section was to examine the system development process in the organisation.
Knowledge Capturing	The purpose of this section was to determine the respondents understanding of knowledge capturing

The construction of the questions needs to measure the concepts the researcher is trying to get answers to, and it is important to include closed-ended and open-ended questions for this purpose (Abbott & McKinney, 2013). The researcher asked open-ended questions to allow respondents a chance to express themselves, and to allow the researcher to see the variation of the group of respondents and close-ended questions to compare answers across the responses to identify patterns in the data (Abbott & McKinney, 2013). Close-ended responses should be ranged in a logical order and the categories should be mutually exclusive (no overlap of questions) and ensure that all responses are covered (Neuman, 2014; Saunders *et al.*, 2009).

The questionnaire sent to the respondents is attached to this dissertation, labelled Annexure A - Questionnaire.

The questionnaire contained dichotomous questions, these are questions where only yes or no answers are accepted (Saunders *et al.*, 2009).

An example of a dichotomous question taken from the questionnaire is shown in:

Were you ever part of a project team that implemented an Information Technology (IT) System in the organisation?	Yes	
	No	

Table 9: Example of a dichotomous question

Many of the questions were Likert-style rating scale questions, these are questions that allow a respondent to indicate how strongly they agree or disagree with a statement (Saunders *et al.*, 2009).

An example of a Likert-scale question taken from the questionnaire:

The transfer of tacit knowledge (knowledge in people's head) is important in ensuring that an organisation's most valuable assets do not walk out the door.	Agree	
	Disagree	
	Neutral	
	Strongly Agree	
	Strongly Disagree	
	Don't know	

These questions were designed to collect the respondents' opinion about the statement. The researcher is conducting an exploratory study to understand the role of knowledge capturing during the requirements elicitation process, and included the rating "neutral", to allow respondents not to respond to a question. The researcher also included the rating "Don't know", to assess employee awareness of the statement and, subsequently, to provide answers to the research questions.

4.9.3 Questionnaire data analysis

After the researcher received the questionnaire in MS Word format, the researcher captured the data in MS Excel where it is recorded with numerical codes, this process is known as coding (Saunders *et al.* (2009). It requires a thorough look at text that was received and converting it in a very systematic manner into measures of significant symbols, words or messages (Neuman (2014).

The researcher used a statistical tool (IBM SPSS) to import the data that was captured on MS Excel. Statistical software packages can be used to assist with automated data analysis (Greener, 2008). This tool makes it easier to fetch the data and automatically create frequency information. Each dataset had its own frequency table showing the frequency of the data, as well as the percentage page.

Here is an example of how a dataset is provided by the software:

How many (IS) / Information Technology (IT) Projects have you been a part of?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 to 2	39	60.9	60.9	60.9
	3 to 5	15	23.4	23.4	93.8
	5 to 10	4	6.3	6.3	100.0
	10 to 15	6	9.4	9.4	70.3
	Total	64	100.0	100.0	

Table 10: Example of dataset

This data from the questionnaires was exported to MS Excel, and the researcher could create graphs based on the frequency table that was created with the statistical software. The researcher created graphs that could be easily readable and was able to illustrate the outcome of the system.

According to Neuman (2014), in order to give a reader a condensed picture of the data that has been collected, a researcher should deliver the data in the form of charts and

graphs. This summarised form of the data is a way of disclosing items of interest about the social world. The statistical program used by the researcher used variables that represent different characteristics about the responses of the participants. This process, known as data coding, means "systematically reorganizing raw data into a format that is easy to analyse using statistics software on computers" (Neuman, 2014:393).

4.9.4 Reliability and Validity

Reliability refers to the ability to produce consistent findings when using the same data collection techniques (Saunders *et al.*, 2009). Three questions can be asked to assess if the data collection was reliable: Will you get the same results with the measure that you have used? Will other observe achieve similar results? Is there transparency in how the data was collected? Reliability also refers to the dependability or consistency of the data and (Neuman, 2014) suggests that the same thinking will occur in identical or similar conditions.

Validity refers to how accurate the data collection findings are (Saunders *et al.*, 2009). It also suggests truthfulness and addresses how well the social reality is measured. It is important that data that has been collected is valid and it is reliable. Reliability is ensuring that the same results will be received under similar conditions (Neuman, 2014) and (Saunders *et al.*, 2009).

Research validity is related to the accuracy and truthfulness of a research study, if research is valid it will demonstrate what exists and will provide a valid measure of what it is supposed to measure (Brink, 1993). We can distinguish between internal and external validity (Campbell & Stanley, 1966). Internal validity is a way to measure if the research was done correctly, and that there are no extra variables that the researcher is not aware of. External validity is the degree to which the research can be applied to different applicable groups, and the researcher should ask him/herself "can the research be applied to the real world?" Reliability deals with consistency, it is the ability

of a research method to deliver the same results when it is repeatedly done. There are many risks that influence validity and reliability.

Brink (1993) identified four possible sources of error that can pose a risk to reliability and validity of the research. The first is that the researcher is usually the data-gathering instrument in a research study, it is important to make sure that the researcher bias will not play a role in the data collection. The researcher of this paper is aware that the way the sample was based could be viewed as biased. The researcher based the sample selection on the roles occupied by the individual in the organization.

The second risk is the respondents to the research. It is possible that respondents will want to make things seem better or worse than what they are, or might attempt to please the researcher by over-or underplaying their responses. The researcher can attempt to increase the response validity by: (1) ensuring that informants are aware of the research and what the purpose of the research is, and (2) keeping accurate and detailed information. The researcher sent an email to the respondents to ensure traceability and reliability. The researcher has a copy of the email that what was received from the respondents, this can be made available upon request to ensure the anonymity of the respondents.

The third risk is the situation or social context risk to reliability and validity, when people respond to a questionnaire in a different social context the response might differ. The researcher used the organisation's email address and all emails were sent to the organisation's formal address, thus setting the scene for the questionnaire, that it is a case study on the organisation.

The fourth risk is the methods of data collection. Reliability and validity depend on the potential for subsequent researchers to be able to reconstruct the original plan, and a clear account of the research design needs to be provided that will ensure that the researcher is not at risk of being accused of unreliable and invalid findings. The

researcher has provided a clear account that the research study was conducted, making available all responses from the respondents.

4.9.5 Response Rate

A total of 150 questionnaires were distributed of which 64 responses were returned, and the overall response rate is 43%. This response represents the participants' sampling in Table 11 as follows:

Sample Group	Frequency	Percent
Broad Understanding about the business and processes	14	22%
Involve in IS implementation	16	25%
Involved in sharing knowledge	20	31%
Technical / Systems Background	14	22%
Total	64	100%

Table 11: Sample Response Rate

4.10 Ethics and Anonymity

4.10.1 Permission

The researcher obtained written permission from the Human Capital Executive to conduct this research in the organisation, this was done to ensure that the organisation is aware of the research that is taking place, and to ensure the organisation that it will be protected.

4.10.2 Confidentiality and Privacy

Confidentiality refers to handling the research in a confidential manner. The email that was sent to the respondents assured that the questionnaire is anonymous.

4.10.3 Voluntary participation and informed consent

The researcher should ensure that the study does not breach legal boundaries, and that accepted ethical standards are followed (Bell, 1999). Informed consent is an ethical principle that participants of a research have been granted a choice in whether they want

to participate in the research (Myers, 2009). Participation in a research study must be voluntary , and it is important that people know what they are being asked to participate in (Neuman, 2014).

In the introduction email that the researcher sent, it was made clear that by completing the questionnaire, the respondents give consent to participate in the research; that the questionnaire is anonymous and that names of respondents will not be used. In addition, the respondents were also informed that their participation was voluntary, and should they wish not to continue, they are free to do so with no negative consequences.

The first question of the questionnaire asked respondents whether they gave their consent to participate in the research as a final measure to ensure it was clear they were under no obligation to assist with the research. As part of the research, a research proposal had to be provided to the ethics committee. Ethics committees play an important role in ensuring that research is done in a proper manner that is not harmful. The ethics committee members are gatekeepers in ensuring that research is done properly.

4.11 Summary

The research methodology and design were the focus of this chapter. IS research is concerned with people and the relationship between technology and people. The process was described by using the research onion as a symbol to identify the different layers that need to be uncovered in the research process.

The first layer that was discussed was the philosophical layer, the researcher had an interpretive take on the study as the premise was to understand the role of knowledge capturing during the elicitations of requirements. This process is performed by individuals

and it is their role and understanding of knowledge and the elicitation process that it is relevant. The research methodology was an interpretive case study using the approach described by (van der Merwe *et al.*, 2005) to confirm the research methodology.

The data collection was described, this included the literature study (secondary data) and questionnaires (primary data). The research participants were selected based on the role they play in the organisation. The last section of the chapter looked at the principles of ethics and anonymity.

Chapter 5 Data Analysis

5.1 Introduction

In this chapter, the empirical investigation is to address the following research objective: To determine how knowledge can be captured effectively during the elicitation of system requirements. The data was collected by the distribution of a self-administered questionnaire, this was informed by the literature review as well as the aim and the objectives of the study: To understand the role of knowledge capturing during the requirements elicitation process in information system development. The layout of the different sections of the questionnaire was explained Table 8: Sections in the questionnaire in Chapter 4, it consisted of four sections. The results will be discussed and presented according to these sections in this chapter.

5.2 Outline of Chapter 5

Table 12: Outline of Chapter 5 provides an outline of the chapter. This chapter discusses the qualitative analysis and the empirical results that were received from the data collection. The discussion is in line with the sections of the questionnaire, and the first section is the demographical information, followed by sections on knowledge management, system requirements and knowledge capturing.

Table 12: Outline of Chapter 5

Outline of Chapter 5			
Section	**Description**	**Sub-section**	**Sub-section description**
5.1	Introduction		
5.2	Outline of Chapter		
5.3	Outline of Chapter	5.3.1	Qualitative Data Analysis
		5.3.2	Section 1 - Biographical /Demographic data of participants
		5.3.3	Section 2 - Knowledge Management

		5.3.4	Section 3 - Systems Requirements
		5.3.5	Section 4 - Knowledge Capturing
5.4	Summary		

5.3 Data Analysis

5.3.1 Qualitative Data Analysis

The qualitative data received was in raw form, this data does not have meaning until it has been processed and analysed and transformed into information that will make it useful Saunders *et al.* (2009).

Quantitative data can be divided into two groups: numerical data which are the values that are measured or counted numerically as quantities of data, and categorical data, which are those values that cannot be measured numerically Saunders *et al.* (2009).
It is important to understand the different types of data when data is being analysed. Analytical software can generate statistics easier and if the scale of measurement is precise, a greater range of analytical techniques are available.

The section below is the exploration and description of the data received from the questionnaires into useable information.

5.3.2 Section 1 - Biographical /Demographic data of participants

This section is an analysis of the demographical data of the participants; it provides characteristics of the population under the study.

Question 1 - I have given consent to participate in this research

All participants were requested to state that they have given consent before to answering all the questions, the purpose of this question is to make respondents aware that the questionnaire will not be used without their consent. This question had to be responded

to by clicking in a checkbox, this indicated if the respondents have given consent or not.

This study consisted of sixty-four (64) respondents, and all respondents have indicated that they have given consent to participative in the questionnaire.

Question2 - How many years have you been with the organisation?

The respondents reported on their number of years in the organisation by selecting one of the five groups in the questionnaire as depicted in Figure 8: Number of years in the organisation. More than a third of the respondents (n=23; 36%) have been with the organisation between 11 and 20 years. The second greatest proportion of respondents (n=15; 24%) have been with the organisation between 6 and 10 years followed by (n=13; 20%) respondents, who have been with the organisation for more than 20 years. The respondents that have been with the organisation between 1 and 5 years were (n=11;17%) with the smallest proportion of the respondents (n=2; 3%) who have been with the organisation for less than a year.

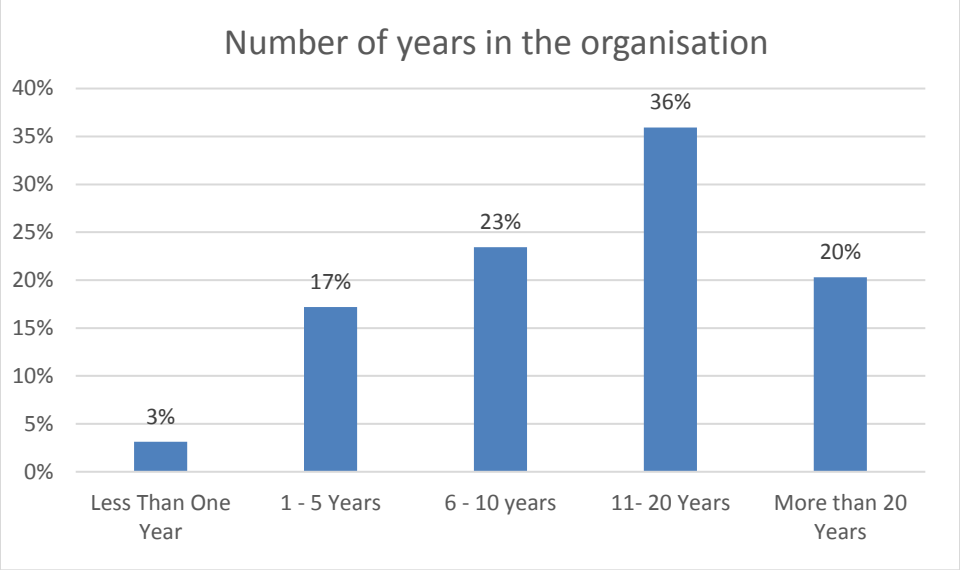

Figure 8: Number of years in the organisation

The HRO is the only one of its kind in South Africa, and the organisation is an ANSP and the air traffic control is the one of primary operational function of the organisations.

Air traffic controllers (ATCs) work in control towers located at airports in South Africa. ATCs use a surveillance system to observe the ATC traffic situations, the controllers issue "clearance" to the aircraft through the communications systems and the aircraft flies through the route that has been identified by using a navigation system (Hansman & Odoni, 2009). This Communication, Navigation and Surveillance (CNS) is the integral functions of the ANSP and requires specialised skill and training through aviation training institutes.

This tenure profile has been confirmed with an HR representative who confirmed that the staff turnover for employees working in the specialised environment is very low.

Question 3 - Were you ever part of a project team that implemented an Information Technology (IT) System in the organisation?

More than two thirds (n=45; 70%) of the respondents have been involved in the implementation of IT systems and (n=19; 30%) have not been part of an IS implementation as shown in Figure 9 : Respondents part of a project team that implemented an Information Technology (IT) System in the organisation.

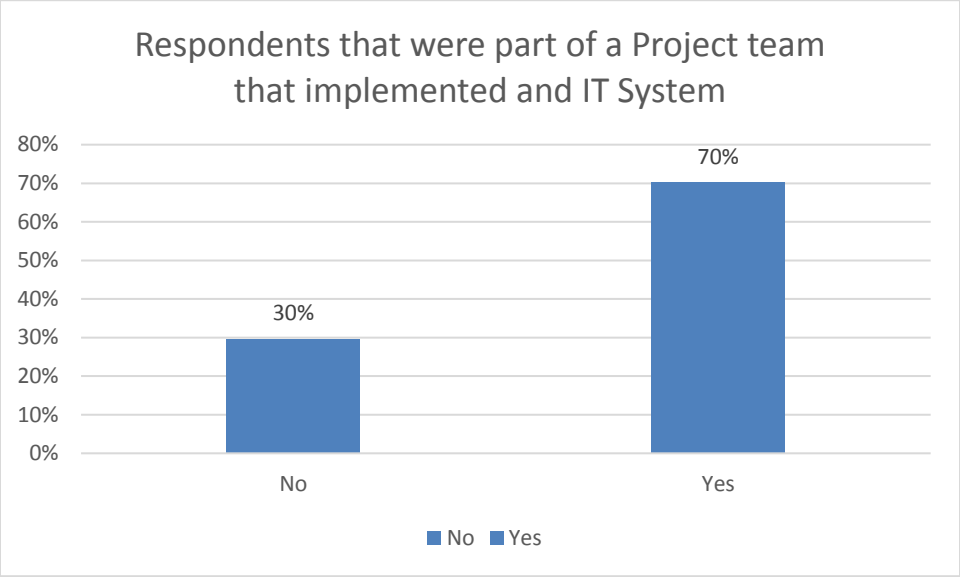

Figure 9 : Respondents part of a project team that implemented an Information Technology (IT) System in the organisation

Question 4 - What is your Age in Years?

As reflected in Figure 10: Age in Years the 41 - 50 age group had the largest proportion of respondents (n=24; 38%), this was followed by the 36 - 40 age group with (n=16; 24%) respondents. The 31 - 35 and the greater than 50 years age group comprised of (n=10; 16%) and (n=8; 13%) respondents respectively. The age group with the smallest proportion of respondents were in the 20-24 age group and only 2% of respondents came from this group.

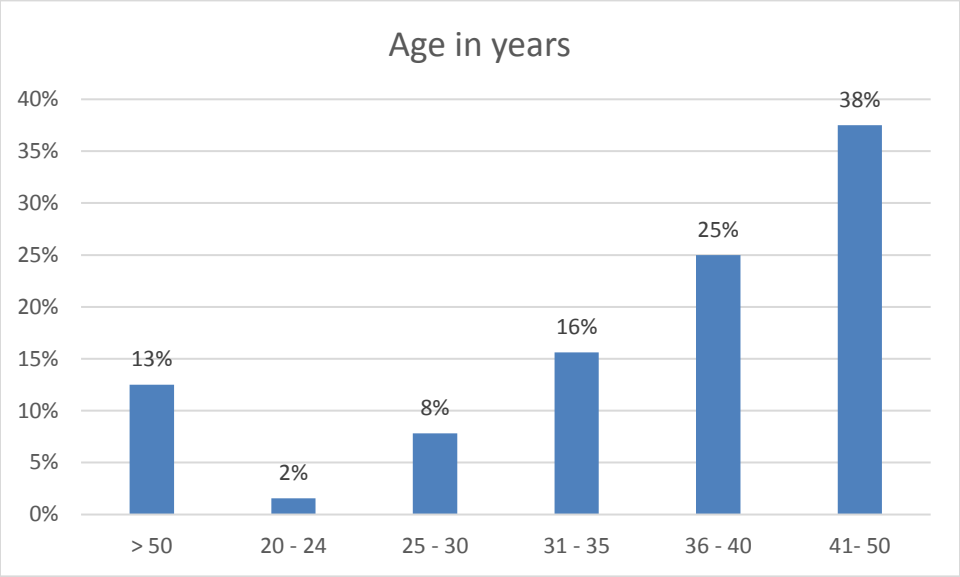

Figure 10: Age in Years

Over 50 % of the respondents were over the age of 40 years. This could be attributed to the fact that the organisation is the only ANSP in South Africa where employees tend to stay longer as the skills obtained and developed in the air traffic and navigation field are highly specialised. This is depicted in Figure 8: Number of years in the organisation, where it shows that employees have the tendency of staying in the organisation for a long time.

Question 5 - How many Information Systems(IS) / Information Technology (IT) Projects have you been a part of?

A total of (n=39; 61%) of the respondents were involved in 0 to 2 IS implementations, followed by (n=15; 23%) of the respondents who were involved in 3 to 5 IS implementations. The smallest proportions of individuals who were part of IT or IS implementations were (n=6; 9%) and (n=4; 6%) respectively.

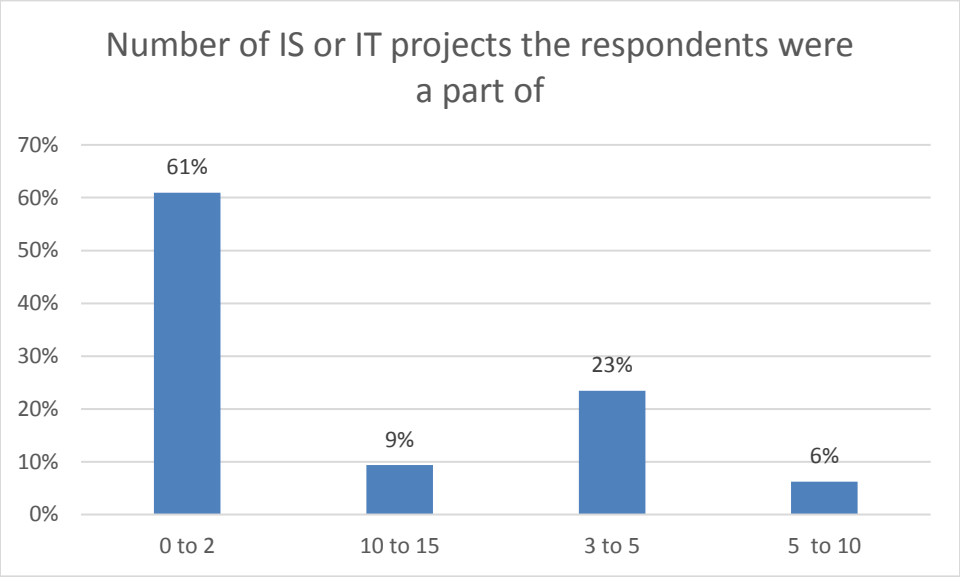

Figure 11: Part of Information Systems (IS) / Information Technology (IT) Projects implementation

Commercial airports are located at different places, and these airports have to satisfy international technical standards to ensure that the interoperability of aircraft safety is maintained across all airports (Hansman & Odoni, 2009). This is a global standard that needs to be maintained as aircrafts fly to different destinations across the globe. This international operations requires systems that are on the same standards globally, as directed by the standards dictated by ICAO.

ATC systems have a very long lifespan (Ahmad & Saxena, 2008). This is indicated by the number of IT or IS projects that employees were part of, systems are implemented every 15 years.

The questions described in the next section contained several rating questions. The purpose of rating questions is to collect opinion data where the respondents are asked how strongly they agree or disagree with a statement or series of statements (Saunders *et al.*, 2009).

5.3.3 Section 2 - Knowledge Management

In this section of the questionnaire, respondents were asked to respond to their understanding of knowledge and KM, and how they think it is applied or should be applied.

Question 1 - Employees are willing to share their knowledge

More than half of the respondents indicated they are willing to share their knowledge, this is a total of 35 out of 64. This was followed by (n=10, 16%) of the respondents who were both in disagreement and neutral towards this statement. A total of (n=6; 9%) of the respondents strongly agreed with this statement and (n=3; 5%) strongly disagreed. The results are displayed in Figure 12: Employees are willing to share their knowledge.

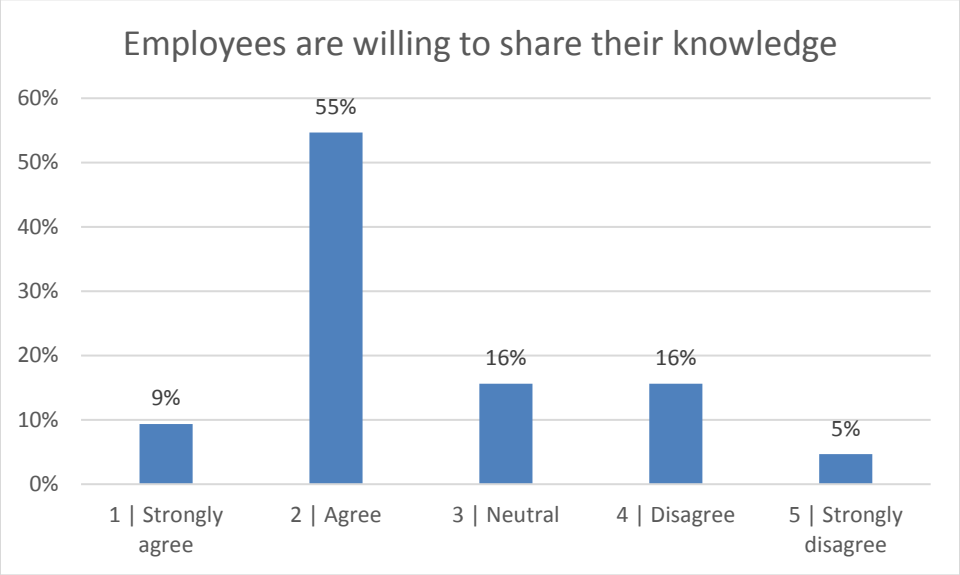

Figure 12: Employees are willing to share their knowledge

Figure 10: Age in Years showed that 38% of the employees are between 41 and 50 years, 25% between 36 and 40 and 13 % are over 50 years old, this is 76% of the sample population. Figure 12: Employees are willing to share their knowledge shows 55% of employees agree that they want to share their knowledge and 9% strongly agrees with this statement. This data is indicative of employees that older employees are willing to share their knowledge.

Question 2 - Knowledge management is important for the operations function within my department

In response to the statement that KM is important for the operations function within my department, the majority of the respondents agreed. It was discovered that (n35; 55%) strongly agreed with this statement and (n=25; 39%) agreed. Only (n=2; 2%) believed they would stay neutral or disagree with the statement. These results are displayed in Figure 13: Knowledge management is important for the operations function within my department.

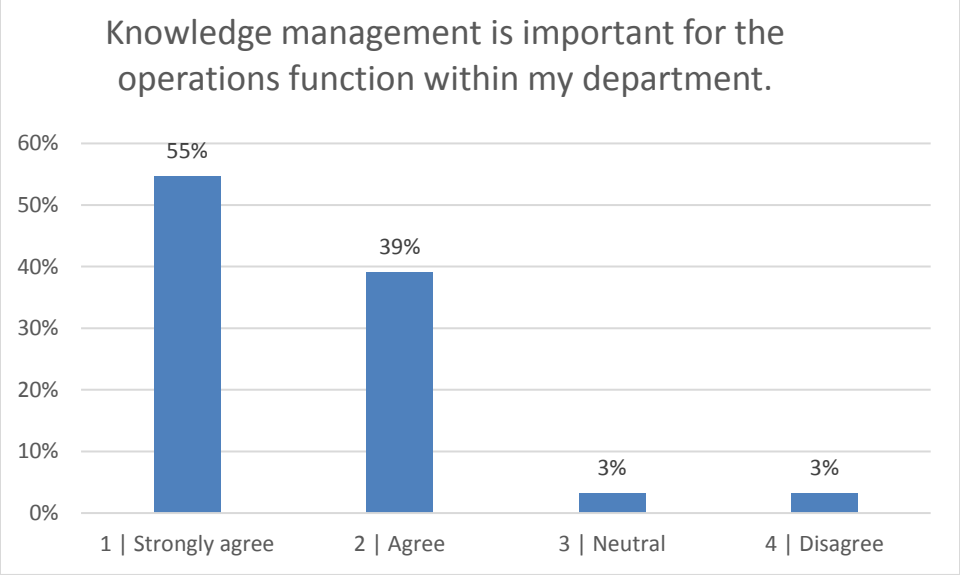

Figure 13: Knowledge management is important for the operations function within my department

Over 80% of the respondents indicate that knowledge management is important for their department, this is a realisation that the knowledge that resides in the employees' department should be managed.

Question 3 - Knowledge management is in a mature stage in the organisation

Half of the respondents disagreed with the statement that knowledge management is in a mature state in the organisation as reflected in Figure 14: Knowledge management is in a mature stage in the organisation, (n=26; 41%) and (n=6; 9%)

disagree and strongly disagree respectively. Less than a quarter of the respondents were neutral (n=15; 23%) in their response to the statement where (n=10; 16%) agreed, (n=6; 9%) strongly agreed and 2% stated that they do not know.

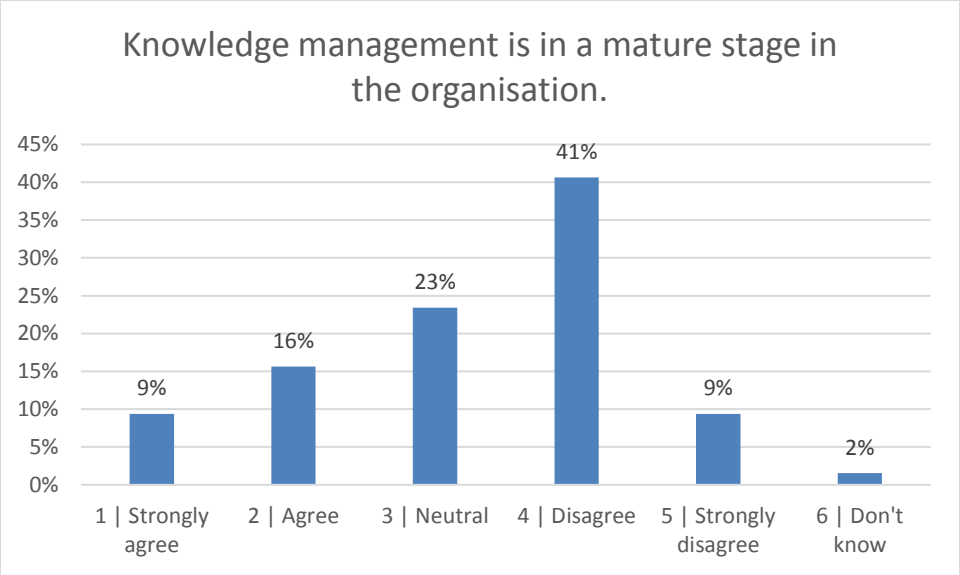

Figure 14: Knowledge management is in a mature stage in the organisation

Respondents are willing to share their knowledge as shown in Figure 12: Employees are willing to share their knowledge, but 41% disagree with the statement that KM is in a mature stage in the organisation. The employees realise how important knowledge is for their department but in relation to the organization, over 50% do not believe that the organisation is in a mature stage

Question 4 - The organisation keeps up with new technology.

Figure 15: The organisation keeps up with new technology shows that many of the respondents (n=28; 44%) and (n=12; 31%) strongly agreed and agreed respectively when asked if the organisation keeps abreast with technology. The remainder of the proportion

was made up of a quarter of the responses with (n=9; 14%) stating that they are neutral in their response; (n=6; 9%) stating that they disagree and 2 % opted to stay neutral in their response.

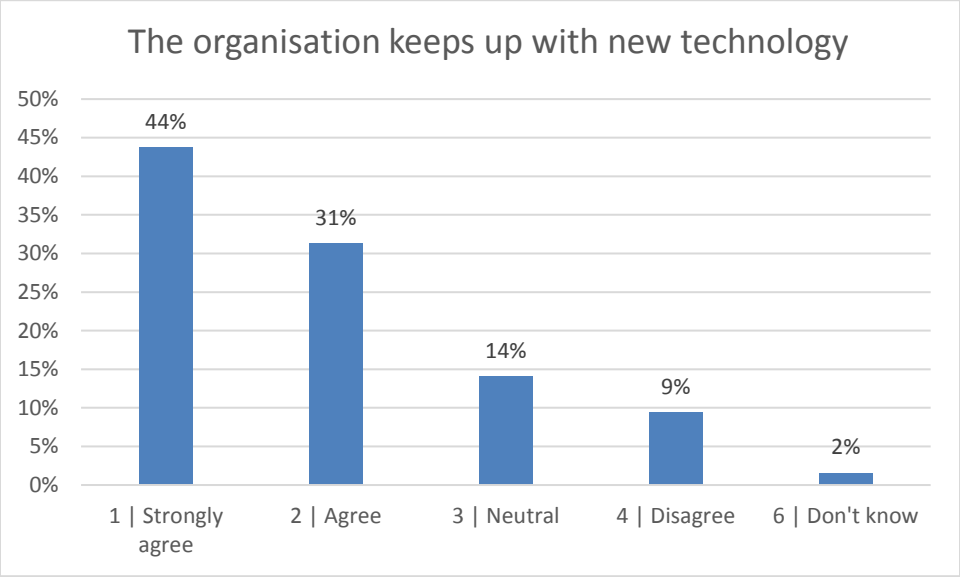

Figure 15: The organisation keeps up with new technology

The organisation works with international airlines and operates on a global level, technology needs to keep abreast with other ANSP's and the organisation also need to abide with the SARPs and policies guide by ICAO. Technology needs to be in line with the market and with the global air traffic management community. This can be seen by the result (over 70%) when respondents were asked if the organisation keeps up with new technology.

Question 5 - Knowledge from retired employees is lost when they leave the organisation.

Figure 16: Knowledge from retired employees are lost when they leave the organisation shows that the majority of respondents believe that knowledge is lost from employees when they retire. The proportion of the respondents that agreed was (n=30; 46%) and a further (n=4; 6%) strongly agree with this statement. The response shows that (n=11; 17%) of respondents are neutral, (n=15; 23%) disagreed and (n=4; 6%) of the respondents strongly disagreed.

Figure 16: Knowledge from retired employees are lost when they leave the organisation

Figure 12: Employees are willing to share their knowledge showed that employees are willing to share their knowledge, yet when asked if knowledge from retired employees are lost, 47% agreed with this statement, 17% were neutral. The maturity of KM in the organisation also showed that 41% of the employees do not agree that KM is in a mature stage.

Question 6 - The transfer of tacit knowledge is important in ensuring that an organisation's most valuable assets do not walk out the door.

The majority of the respondents is of the belief that the knowledge that resides in people's heads (tacit knowledge) should not leave the organisation. The respondents who agreed and strongly agreed were (n=24; 38%) and (n=31; 48%) respectively, (n=6; 9%) were neutral and respondents who disagreed and strongly disagreed were both 1%.

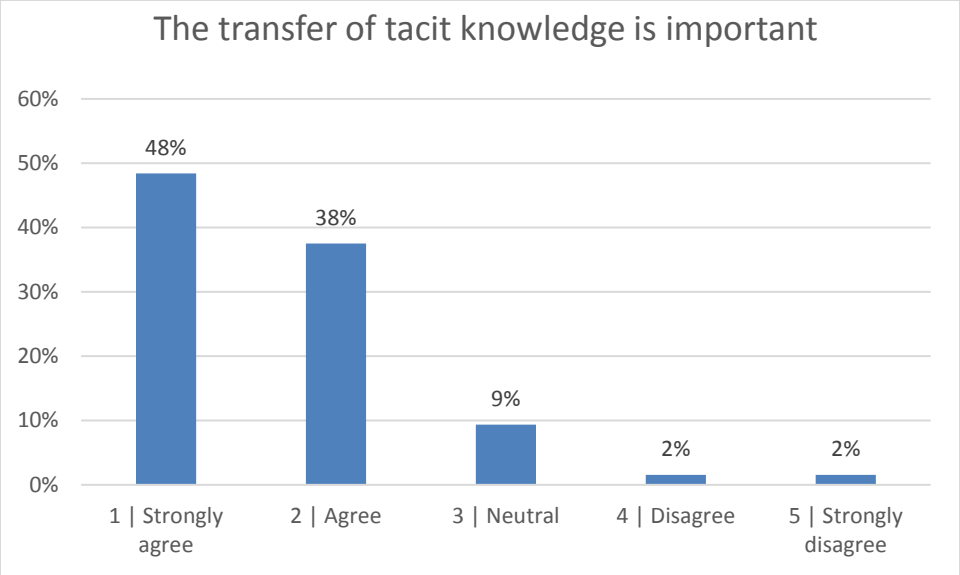

Figure 17: The transfer of tacit knowledge is important

Over 60 % of the respondents in the organisation are willing to share their knowledge *(Figure 12: Employees are willing to share their knowledge)* and 86% agree that the transfer of tacit knowledge is important. The organisation has a lot of skill and experience (*Figure 8: Number of years in the organisation)* with the number of years that employees stay in the organisation.

Question 7 - Support for knowledge management understanding is freely available.
When asked if support for KM is freely available in the organisation, (n=27; 42%) and (n=5; 8%) of the respondents strongly agree and agree respectively, this is over more than half of the respondents who believe KM support is accessible. A total of (n=15; 23%) and (n=13; 23%) of the respondents disagree and are neutral, with 1% stating that either they do not agree or they strongly disagree. 3% of the respondents who did not provide a response and left the response blank.

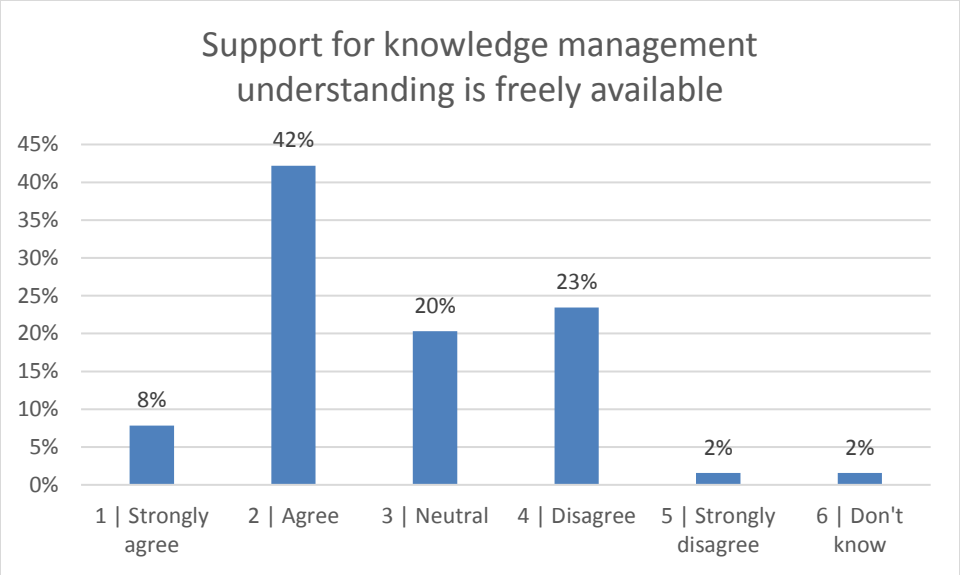

Figure 18: Support for knowledge management understanding is freely available

The result for support for knowledge management in the organisation is dispersed, 42% of the employees agrees with the statement that support for KM is freely available and 23 % disagreeing with this statement. A fifth of the respondent, 20%, has a neutral response. Employees agree that KM is important for the functions in their department Figure *13: Knowledge management is important for the operations function within my department* but the support for management is not clear. The tenure of respondents in the organisation is long, over 20% of the respondents have been with the company for more than 20 years and 36% have been with the company for 11 to 20 years. However, the support for KM cannot be established by the response that was provided.

5.3.4 Section 3 - Systems Requirements

The following questions were asked to understand the system requirements process, how it is done and what the involvement of users is when IS are developed.

Question 1 - There is a standard process of developing system requirements for a new/existing Information System.

In the statement, there is a standard process of developing system requirements for a new/existing IS, (n=2; 3%) of the respondents strongly agree and (n=25; 39%) agree.

However, (n=16; 25%) of the respondents were neutral with regard to this statement, and furthermore, (n=12; 14%) disagreed, (n=2; 3%) strongly disagreed and (n=7; 11%) stated that they do not know. This is reflected Figure 19: Standard process of developing system requirements.

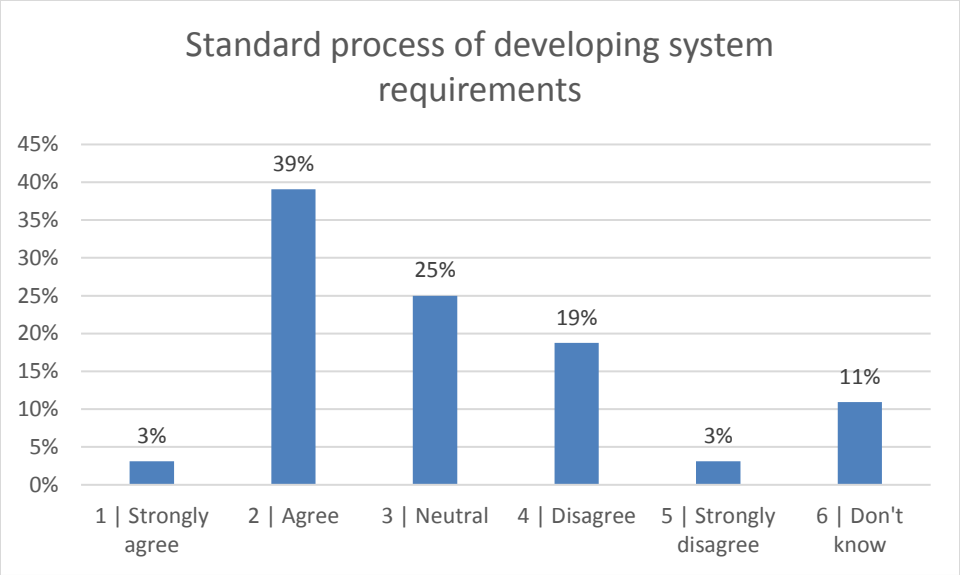

Figure 19: Standard process of developing system requirements

Over 30% of the respondents have been part of an information technology or IS implementation, according to the information in Figure 11: Part of Information Systems (IS) / Information Technology (IT) Projects implementation and 39% believe that there is a standard process in place when system requirements are being developed. *Figure 12: Employees are willing to share their* knowledge shows that over 60 % of the respondents are willing to share their knowledge.

Question 2 – End-users work closely together during the development of system requirements.

The result from the statement that assess if end-users work closely saw (n=3; 5%) of the respondents stating they strongly agree as shown Figure 20: End-users work closely together during the development of system requirement. However, (n=21; 33%) and (n=20; 31) said that they agree and are neutral respectively, (n=14; 19%) stated that they disagree, (n=3; 5%) strongly disagree as well as they do not know.

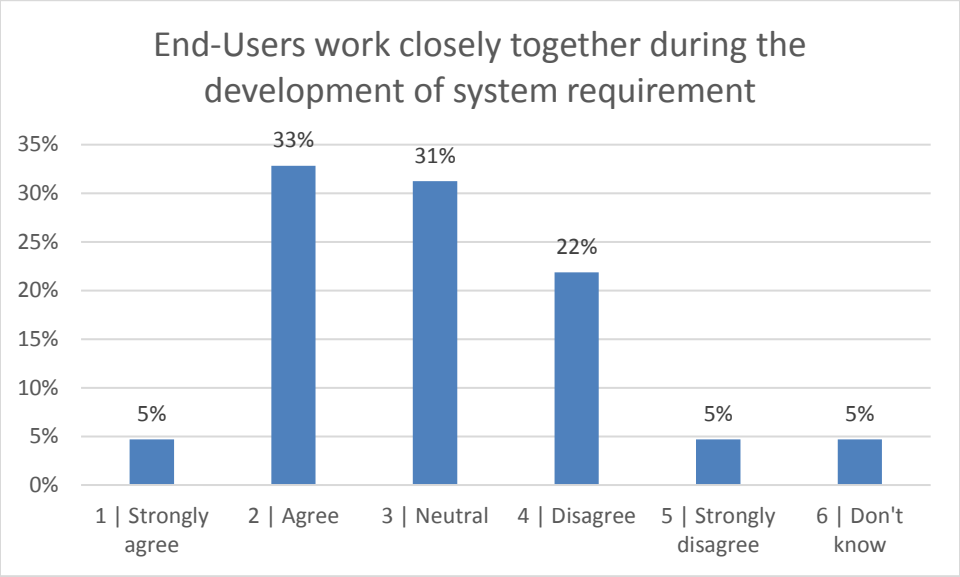

Figure 20: End-users work closely together during the development of system requirement

Over 70% of the respondents were part of a project team that implemented an IT system as shown in Figure 9. However, 31% of the respondents had a neutral response when asked if end-users work closely together when system requirement are developed, this is almost half of the respondents indicating that end-users worked closely in the development of system requirements, 22% disagreed.

Question 3 - The development of system requirements involves all relevant parties.

In response to the statement that the development of IS involves all parties, (n=9; 14 %) of the respondents said that they strongly agree, (n=25; 39%) agree, (n=8; 12%) were neutral, (n=18; 28%) disagree, (n=3; 5%) strongly disagree and (n=1; 2%) said that they do not know, this is reflected in Figure 21: The development of system requirements involves all relevant parties.

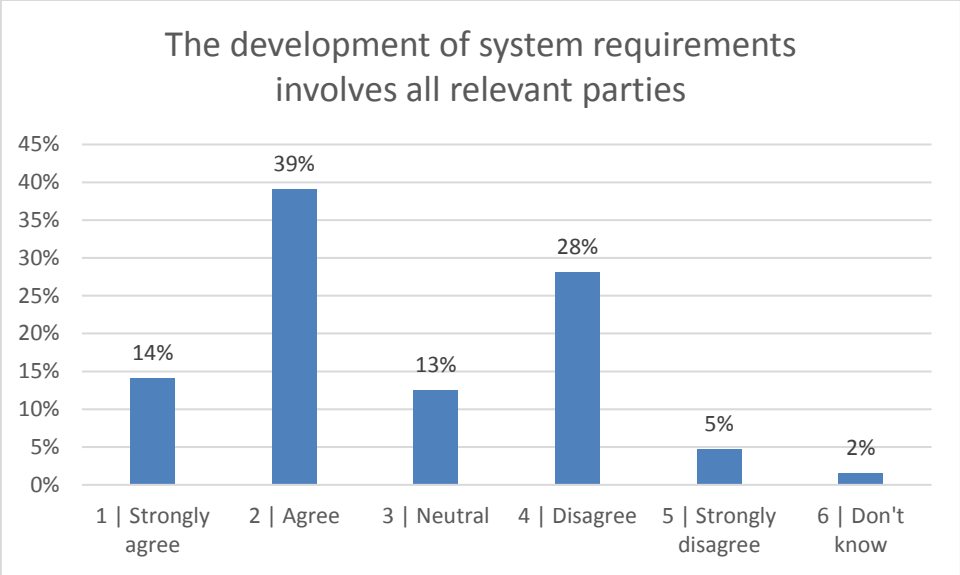

Figure 21: The development of system requirements involves all relevant parties

The results of *Figure 20: End-users work closely together during the development of system requirement* and the results of Figure 21: The development of system requirements involves all relevant parties, are very similar. Over a third of the respondents agree that the development of system requirements involves relevant stakeholders and end-users.

Question 4 - The outcomes of system requirements is freely available to all employees.

To asses if employees think that the outcomes of system requirements are freely available, (n=16; 25%) stated they agree, and (n=20; 31%) said that they disagree with this statement. Furthermore, (n=21; 33%) of the respondents replied with a neutral response, (n=2; 3%) stated strongly agree, (n=3; 5%) strongly disagreed and 2% stated that they do not know, this is reflected in Figure 22: The outcomes of system requirements is freely available to all employees.

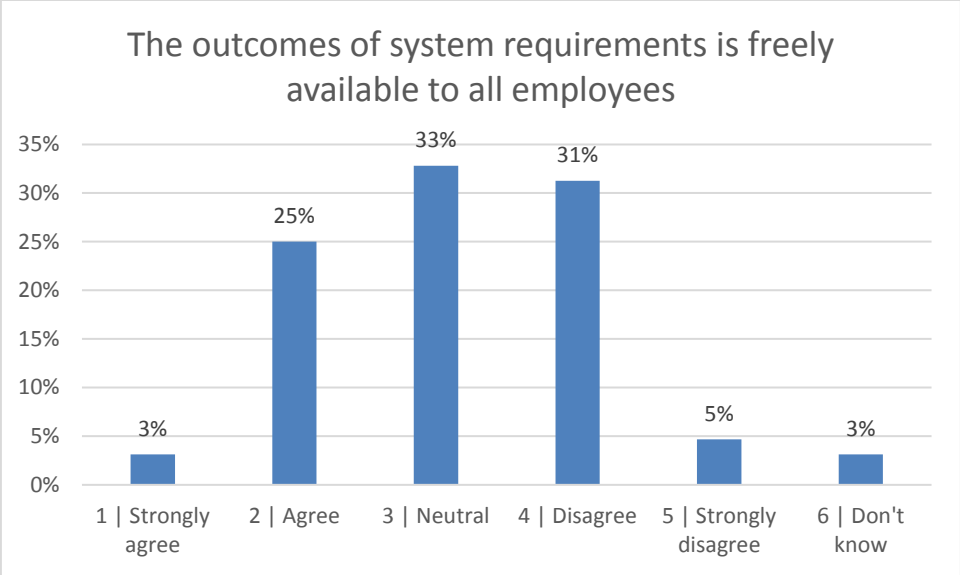

Figure 22: The outcomes of system requirements is freely available to all employees

Over 70% of the respondent has been a part of a project that implemented an IT system and over a third, 39% has been part of an IT/IS implementation. In Figure *22: The* outcomes of system requirements is freely available to all employees, 31 % of the respondents stated that they disagree that the system requirements are freely available.

5.3.5 Section 4 - Knowledge Capturing

The next set of questions was posed to understand knowledge capturing. Do employees feel that knowledge is being captured? Are they willing to share knowledge that will allow the capturing thereof? The questions also attempted to understand if employees are of the belief that what they know is not something that is currently captured.

Question 1 - I am not afraid to share my experiences in my line of work.

Figure 23: I am not afraid to share my experiences in my line of work shows that most of the respondents stated they were not afraid to share their knowledge with (n=27; 58%) who strongly agree and (n=28; 43%) who agree) with the statement. There were (n=3; 5%) neutral respondents and, (n=4; 6%) and (n=1; 2%) who disagree and strongly disagree respectively. There were 2% of the respondents who did not make a selection.

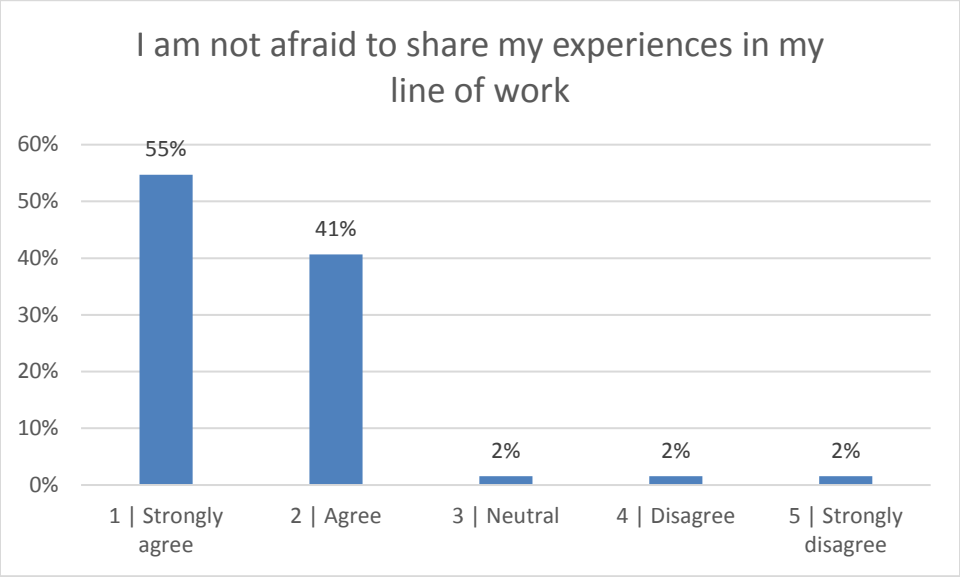

Figure 23: I am not afraid to share my experiences in my line of work

The results from Figure 23: I am not afraid to share my experiences in my line of work is in line with the results from Figure 12: Employees are willing to share their knowledge and Figure 13: Knowledge management is important for the operations function within my department, the employees of the organisation are willing to share their knowledge.

Question 2 - There are situations where decisions depend on my experience rather than a step by step procedure.

Respondents had to identify if there have been situations that required them to depend on what they know instead of a procedure that has been put in place, the results are shown in Figure 24: Decisions depend on my experience rather than a step by step procedure. An overwhelming (n=31; 48%) of the respondents agreed with this statement, followed by (n=23; 36% of the respondents who strongly agree. The remainder of the proportion responded with (n=7; 11%) and (n=3; 5%) for being neutral and disagreeing respectively.

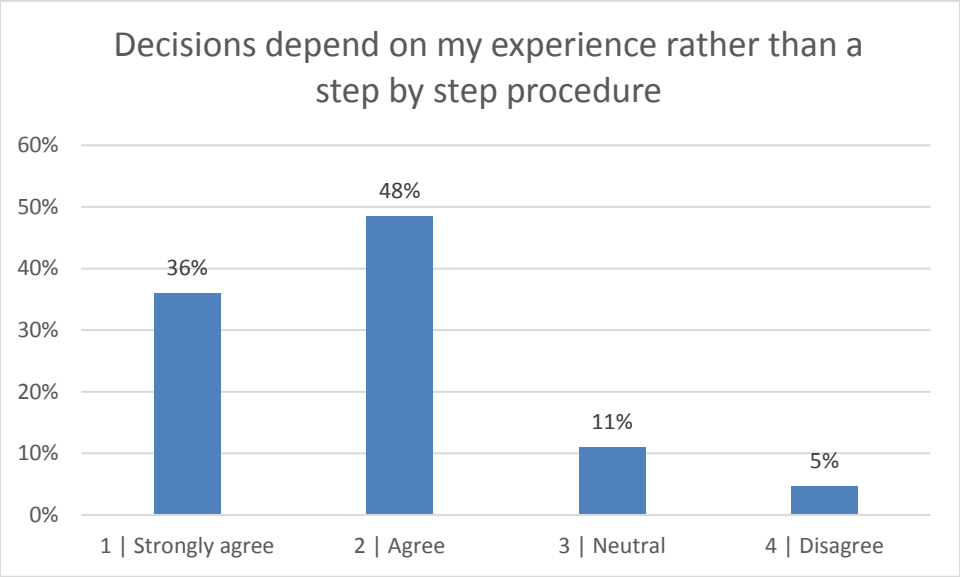

Figure 24: Decisions depend on my experience rather than a step by step procedure

The HRO is guided by procedures that provide direction on how the air traffic control and all related processed should be followed. When asked if there are situations where employees must rely on their experience rather that procedure over 80% of the respondents agreed with this statement as reflected in Figure 24: Decisions depend on my experience rather than a step by step procedure.

Question 3 - Employee knowledge is captured during the requirements sessions.

In assessing if employee knowledge is captured during the requirements sessions, (n=22; 37%) respondents agreed, (n=11; 17%) were neutral and (n=19; 30 %) disagreed with this statement. A further (n=6; 9 %) stated that they don't know and while (n=4; 6%) and (n=2; 3%) stated they strongly agree and strongly disagree respectively.

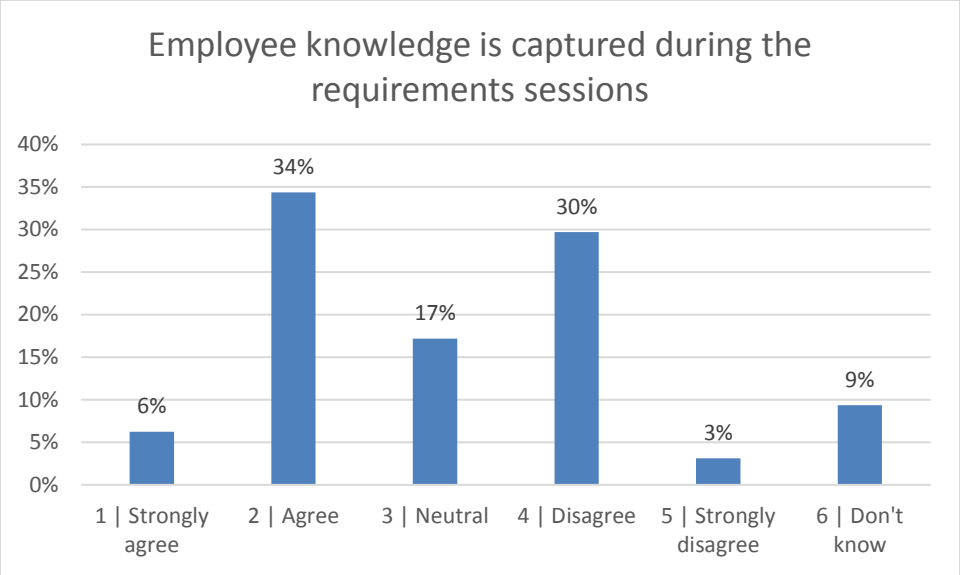

Figure 25: Employee knowledge is captured during the requirements sessions

A third of the respondents agrees and disagree that employee knowledge is captured during the requirements session with 17% that had a neutral response.

Question 4 - All knowledge captured should be available for all employees.

A little over two thirds of the respondents agreed that knowledge that is captured should be available to employees. A total of 27 respondents (n=27; 42%) stated that they strongly agree and (n=28; 44) % said that they agree. The remainder of the proportion responded with (n=3; 5%) neutral, (n=4; 6%) stating that they disagree and 1% that did not make a selection and strongly disagreed.

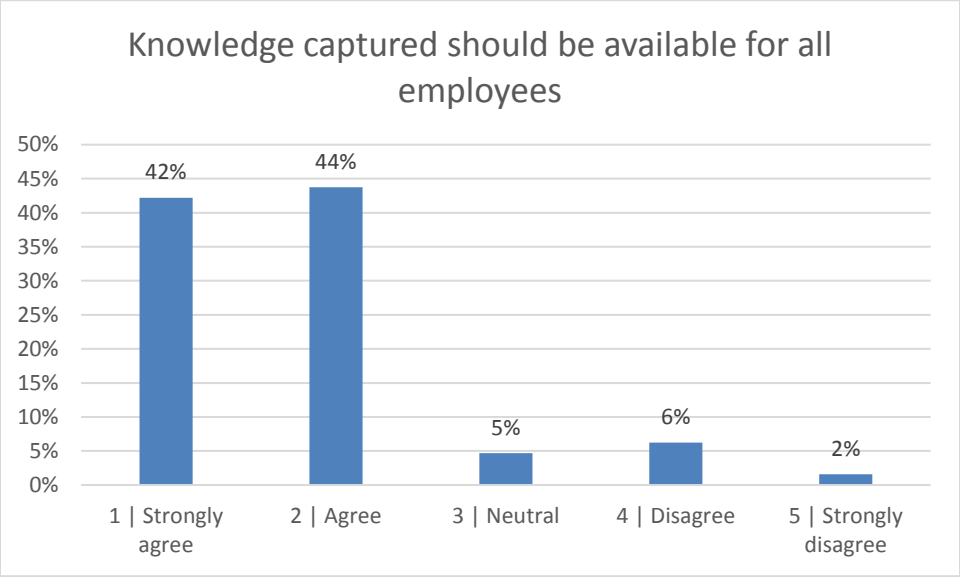

Figure 26: Knowledge captured should be available for all employees

Over a third of the employees' states that knowledge is not captured during requirements elicitation, however over 80% believe that knowledge captured should be available to all employees.

5.4 Summary

This chapter contained figure formats of the data that was gathered from the developed questionnaire. The findings of the data gathered was presented according to the following sections: demographical information, KM, system requirements and knowledge capturing.

The respondents have a long to tenure at the organisation, 36% have been with the organisation for 11 to 20 years and 20% have been with the organisation for more than 20 years. The respondents have indicated that they are willing to share their knowledge but knowledge is not retained when retired employees leave the organisation.

KM is important in their daily operations and over 80% stated that some decisions depend on experience rather than procedure. Even though the respondents indicated their willingness to share experience and to share knowledge there was not an indicator that

the system requirements processes are standard. The maturity of KM has also not been established.

The next chapter will analyse and interpret the data with reference to the literature and the theoretical framework that the researcher has identified. In addition, future research will be discussed and identified.

Chapter 6 Discussions and Recommendation

6.1 Introduction

The focus of the study was to understand the role of knowledge capturing during the requirements elicitation process. This chapter provides an overview, main findings and recommendations of the study.

6.2 Outline of Chapter 6

Table 13: Outline of Chapter 6 provides an outline of the final chapter.

Table 13: Outline of Chapter 6

Outline of Chapter 6			
Section	**Description**	**Sub-section**	**Sub-section description**
6.1	Introduction		
6.2	Outline of Chapter		
6.3	Overview		
6.4	Results and Discussion	6.4.1	Demographical Data
		6.4.2	Research Questions and objectives
6.5	Limitations of Study		
6.6	Recommendation		

6.3 Overview of the dissertation

Chapter 1 provided an explanation of the problem statement as well as the rationale for the study.

In Chapter 2, KM, knowledge capturing and the description of an HRO was scrutinised. The KM area with an understanding of data and information was put into context. The researcher looked at how knowledge capturing was done and scrutinised from an HRO perspective.

Chapter 3 focused on requirements elicitation, its role in the system development life-cycle and how this process is executed. The researcher considered the business analyst book of knowledge (BABOK), which served as a guide on how to conduct requirement elicitation in a business contact context. BABOK provided different techniques but none of the techniques identified had knowledge capturing as an element that needed to be considered.

In chapter 4, the research methodology and design was broken down. The researcher discussed the approaches that are qualitative, quantitative or mixed methods. The researcher explained the research strategy as well as how data collection was conducted. The data collected in this research was primary and secondary data, the secondary data was based on literature study collected by the researcher, and the primary data was collected using a questionnaire as a data collection instrument.

In Chapter 5, the results from the self-administered questionnaire were analysed, the researcher collected the data from the respondents and captured the information in an MS Excel spreadsheet. The researcher used statistical software to convert it into a more reader-friendly format, by which the user used MS Excel to create graphs. The purpose of the graphs was to illustrate the different outcomes of the data provided in the questionnaire.

This chapter, Chapter 6, is a discussion of the findings in relation to the literature study that was done as well as the questionnaire that was completed. This chapter will conclude with a discussion and recommendations of the study and future research possibilities.

6.4 Results and Discussion

This section presents an interpretation of the findings of the study. This will be presented and discussed in response to the research questions as well as the aims and the objectives that were identified.

The primary research question of this study is: How can knowledge be captured effectively during the elicitation of system requirements in a high-reliability organisation? The secondary questions that the researcher attempted to answer are: What constitutes effective capturing of knowledge? And how do you identify knowledge artefacts during the elicitation of system requirements?

The elicitation of requirements is a process that involves different stakeholders in the organisation. Each stakeholder brings their own experience and knowledge, this process of information gathering creates an opportunity for stakeholders to explain their expertise and experience. In an HRO there is no room for error, lives are at stake and safety is the first concern. For this reason, decisions that are made must consider different options. The elicitation process provides an opportunity to discuss these decisions that were made and even if the experience and knowledge are not captured and acted upon in the IS, the knowledge would be available for future reference.

6.4.1 Demographical data

The demographic data reveals that most of the subjects included in this dissertation have been with the organisation for a long period, the largest part of the respondents have been with the organisation between a period of 11 and 20 years (36%). The second largest part of the respondents has been in the organisation for more than 20 years. This is amplified by the age of the respondents of the study, 58% of the respondents are between the ages of 41 and 50 years old, 25% are between 36 and 40 years old and 13% is older than 50 years.

The air traffic control and management environment are highly specialised, and employees train extensively to be able to operate in this environment. Before ATC trainees can reach a level where they are able to switch between strategies and procedures ‘on-the-go’ as well as can expedite air traffic safely, at least four years of intensive training is required (Borst, Visser, Van Paassen & Mulder, 2016). The organisation is the only of its kind in South

Africa. Job opportunities for people who want to work in this environment are few and far between, and this leads to employees staying in this organisation for a long time.

Over two thirds of the respondents (70%) indicated that they were part of an IS or IT systems implementation. The organisation is highly technical and there is a heavy reliance on the knowledge of employees, the IS systems and the employees' input into the IS systems, to keep the high-availability constantly accessible.

6.4.2 Research questions and objective of the study

RQ1 - How can knowledge be captured effectively during the elicitation of system requirements in a high-reliability organisation?

The respondents in this study are not afraid to share their experiences in their line of work, over 85% alluded to this. Even though ideas are created in the minds of individuals there is still interaction required to develop these ideas into action and thus contribute to the creation and development of new knowledge (Nonaka, 1994).

New systems that are implemented for air traffic controllers must be introduced within the context of the environment, when software engineers build systems, they are based on the official rules as well as the documentation that is required by the International Civil Aviation Organisation (ICAO, 2017; MacKay, 1999). The respondents were asked if they believe that situations arise where decisions are dependent on experience instead of a step by step procedure and 84% of the respondents agreed with this statement.

Knowledge is developed according to own preset methods, and experience provides memories that guide understanding to what needs to be done in certain situations, these experiences form a repository of tacit and explicit knowledge. Experience and how people react and operate in given situations is not always captured in IS, situations occur that might not be in a procedure but based on a skill set that was developed through

experiences. When an incident occurred in an HRO, procedures were adjusted to fit to the situation, and it proved that individuals relied on past experiences to regain control.

The process of knowledge capturing is designed to elicit both tacit and explicit knowledge. During this process, knowledge is identified and located, represented and stored and once this is completed, it is validated. In response to the questionnaire statement: Employee knowledge is captured during the requirements elicitation phase, 17% of the respondents were neutral, 30% disagreed and 9 % stated that they do not know. It appears that over half of the respondents were leaning towards an unclear view or disagreed with this statement.

Once knowledge has been captured it should be made available for organisational consumption, this will make people aware of the knowledge that is available in the organisation. Over 80% of the respondents agreed that knowledge should be shared with the organisation.

Once knowledge has been identified and created, it should be shared. Timing is important for the sharing of knowledge. Employees tend to seek knowledge outside the boundaries of their environment because they do not know that knowledge is available within the organisation.

Some organisations require employees to write articles based on their experiences or to speak at conferences or marketing events that would inform people of their activities or to promote the organisation. In doing so, employees are not providing a true reflection of their knowledge; instead they become subject matter experts because they have been training for a period.

RQ2: What constitutes effective capturing of knowledge?

The respondents were asked if they feel that KM is important for the operations in their department, this is to assess how KM can be used in day-to-day functions. Over two

thirds of the respondents said that they agree that employees are willing to share their knowledge, 55% said they agree and 9% said strongly agree. This could be an indication that people are indeed willing to share information and that it is important that there is tools place to allow people to share information.

The researcher wants to have a perspective of what people believe the maturity of the organisation is. An estimated 41% disagreed with the statement that KM is in the mature stage. A total of 23% of the respondents gave a neutral response, this could mean that people are unaware of the statistics, there is also a 2% total of people that said they don't know.

Respondents were asked if they believe if knowledge of retired employees is being captured. Over 50% believe that knowledge is lost from employees when they retire. This could be an indication that people are not aware of any measures that are in place to make sure that when people do retire, they leave behind invaluable knowledge to the benefit of the organisation.

RQ3: How do you identify knowledge artefacts during the elicitation of system requirements?

Sharing of knowledge in an organisation has the benefit of people learning and growing, and in addition, the organisation also gains a competitive advantage. If teams shared the responsibility of explicit outcomes for an organisation, they have access to shared knowledge across the domain.

Over two thirds of the respondents said that they agree that employees are willing to share their knowledge, 55% said they agree, and 9% said they strongly agreed. This could be an indication that people are indeed willing to share information and that it is important that the tools are in place to allow people to share information.

The IS systems used by the organisation are designed to prevent crashes, they are complex systems that need to have the ability to interact with airplanes from all over the world. The technology must be the latest to ensure that the rules and regulations set up by ICAO are adhered to. Over 70% of the respondents agreed that the organisation keeps up with new technology, this shows that the respondents are aware of the importance of new technologies in the organisation. It could be that they understand the need to be in line with other ANSPs.

It is easy to manage and locate explicit knowledge, and this knowledge is visible and searchable. Tacit knowledge is not as easily accessible and has been developed over time by experience and different situations that are not always preempted. Respondents were asked if they think that knowledge in people's heads is important to be transferred and 86% of the respondents agreed with the statement.

When a need for a system exists, there are certain processes that need to be followed, and there are different methodologies that companies can put into place. In order to understand whether people know if there is a process development system requirement this question was posed to respondents.

A total of 16% of the respondents were neutral when asked if there is a standard process of conducting system requirements once again a neutral response means that people do not want to give their opinion. Of the respondents, 42% agreed with the statement while 3% strongly agreed so this indicates that there is a process when a new and existing system is implemented in an organisation.

Only 5% of respondents said they don't know, this could mean that they are not aware of what's happening in the organisation, 5% strongly disagreed with this, meaning that they do not feel that end- users are involved when systems are developed and 22% disagree completely.

One of the important activities that need to take place during requirements elicitation is the identification of stakeholders, this is to ensure that all the relevant people that are involved in the IS development have been identified. The stakeholders that are involved in an ISD project shares explicit and tacit knowledge, and this will allow stakeholders to learn and access knowledge from each other and the different domains as departments are interrelated.

Systems are developed for people; therefore there is a need to have all the relevant people involved when a system is developed. Systems cannot function in isolation as they are interlinked and if one is affected, there is a chain reaction that affects other systems. If an organisation wants to work optimally using all the different functions and departments in the organisation, there is a need for different departments to work together. When asked if the respondents feel the development of system requirements involves all relevant parties, 59% said they strongly agree, and 12% said that they agree. This is an indication that the respondents believe all relevant people are involved during the development of the requirements.

6.5 Contribution – The elicitation of requirements and the alignment with an HRO

It has been established in section 3.4.1 that the unified model for requirements elicitation identifies the different activities that needs to be performed during the requirement elicitation process.

In order to establish how the HRO characteristics identified in the previous section relates to the requirements elicitation process laid out by Hickey and Davis (2004), the HRO characteristics are shown in Figure 27: Requirements elicitation in an HRO. This view was obtained by synthesising requirements elicitation elements from the literature to Hickey and Davis (2004) view (refer black text) and then to enrich it with the findings for HRO's based on the data collection questionnaire (refer red text).

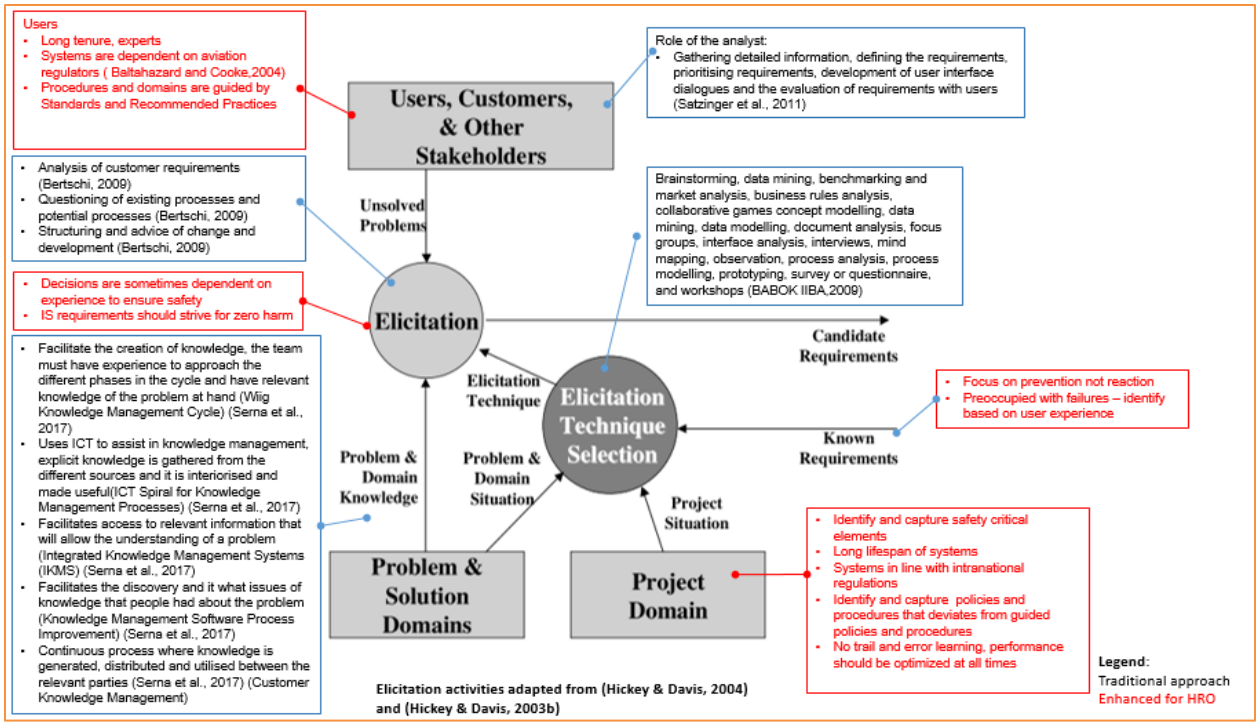

Figure 27: Requirements elicitation in an HRO

The elicitation of requirements to develop an information system is a knowledge-intensive process. Ensuring that the delivered solution satisfies business needs and adhere to business requirements requires clear and compelling user engagements. There is a need for integrative collaboration and sharing of knowledge from different domains to deliver a successful IS. The elicitation process involves various stakeholders; which is dependent on the size of the system or the size of the project. The stakeholder who uses the current system or those who will be using the proposed system is the primary source of information.

During the elicitation process, a proper understanding of the business needs must be articulated and documented. The information gathered from stakeholders' stems from the tacit and intacit knowledge that is based on the individuals experience as well as their reactions in certain situations. In the literature study, the researcher looked at the decision making during an emergency in an HRO; the author described two circumstances. One case required a step by step approach to address the challenge at hand; the other case required the individuals to think on their feet and to use their

experience based on prior experience and actions taken in a similar situation. This decision-making process is an example of the tacit and intacit knowledge possessed by individuals that will emerge when faced with certain situations.

The out-of-the-box thinking is the tacit knowledge that resides in people heads and will come fort when the need arises. Expert knowledge is tacit knowledge, to develop an efficient system, acquisition and transmission of knowledge are required.

6.5.1 Traditional model of requirements elicitation

The case study is an HRO in the aviation industry, incidents such as bird strikes and change in weather conditions can happen at any time, it cannot be controlled. These incidents or safety occurrences have an impact on people's lives, changes in weather conditions could lead to an airplane not being able to land on time. The systems managing these operations must be high reliability systems working optimally at all time.

During the elicitation process, the analyst performs a series of activities, the purpose of the events is to unify all the stakeholders and to assist in reaching a shared understanding of what the requirements are and how it will be addressed (Hickey & Davis, 2004).
Hickey and Davis developed a model that highlights the knowledge needed to gather requirements from users effectively.

The model states that users, customers and other stakeholders have unsolved problems, and these issues can be addressed by elicitation, an activity that uncovers challenges that need to be solved. The model identifies three categories that play a role in elicitation; the first category is the problem domain, this indicates how well the problem is understood, the type of application domain as well as the complexity of the problem. Secondly, the model suggests the solution domain this is the type of solution anticipated or whether the solution will be bought or developed. The third category is the project domain that includes the organisation and the individuals involved in the project.

The model follows the traditional approach when requirements are gathered. A problem was identified, and different functional areas work together to establish a solution. HRO's focus on failures, and what procedures and activities should be put in place to create a zero harm environment and IS.

In the following section, the model is adapted to show how the requirements elicitation process and knowledge capturing can be optimised for an HRO.

6.5.2 Adapted model of requirements elicitation

The process defined by Hickey and Davis explains the requirements process for a traditional IS, in an HRO the approach to the elicitation process is different. Figure 27: Requirements elicitation in an HRO indicates how elicitation and knowledge capturing should be adapted for an HRO, the different elements of the model have been dichotomised to illustrate the role of knowledge capturing during requirements elicitation in an HRO.

Users, customers and stakeholders

The users, customers and stakeholders are part of the elicitation process; they share a common understanding of what the IS needs to achieve. In the adapted version of the model, the first bullet, long tenure, experts, is based on the findings of the study that showed employees had been with the company for a long time.

The users at the HRO has a long tenure in the organisation; they are referred to as specialists and have become experts in their fields. The systems deployed and used are dependent on aviation regulations, all operations should be aligned to ICAO, an international body where the rules and regulations apply to all ANSP's across the globe. Part of the operations includes interactions with pilots and airlines from around the world; it is imperative that procedures and guides be guided by the standard and recommended processes.

The study showed that staff turnover in the company is very low, this extended stay could be tributed to the organisation having its own aviation training company, providing skills, on the job training and educating new students and existing personnel. In a traditional IS, training of employees could be delayed, but employee training in an HRO requires a constant update and keeping abreast with the changing technologies of the aviation industry.

This training pipeline created by the aviation training academy keeps improving as users who have been through the training end up in specialised positions or managerial positions. Seventy percent of the respondents indicated that they had been part of a project team that implemented an IT system, this sharing of expertise and knowledge process comes from the knowledge that has been through the pipeline. The knowledge that was acquired and obtained is filtered throughout the organisation, and it is recycled, capturing this knowledge that has been reused throughout the organisation contribute to the expertise of the ANSP.

The second and third bullets: Systems are dependent on regulators and procedures and domains are guided by standards and Recommendations practises; are based on the study that showed the HRO is regulated by international standards and regulations, and that users, customers and stakeholders are expected to adhere to the regulations.
The international airline industry operates in different time zones, the communication navigation and surveillance systems need to be operational and available 24/7, and it must align with the aviation regulations. Over 80% of the respondents agreed that decisions made relies mostly on their experience and not so much on a step by procedure.

Design and development of IS must be aware and consider the different requirements as well as the different stakeholders when deploying systems.

There are different stakeholders involved when a new or an enhancement to an IS must take place; the team consists of stakeholders from cross-functional areas in the

organisation. The combination of different expertise in different functional areas provides expert advice to ensure the integration of the system into the larger organisation.

The facilitation of the functional areas to gather requirements are usually done by an analyst, who uses different elicitation techniques to establish the business requirements and how this will translate into the system requirements. This process provides the opportunity to gather and capture knowledge. When asked if employee knowledge is captured during requirement sessions, 34 % agreed, 30% disagreed, and 17 % of the respondents had a neutral response. The requirements gathering process provides a platform where knowledge and experience that directly relates to the operational environment can be shared, disseminated and captured.

Problem Solution Domains

The organisation is dedicated to safety; this includes the safety of the multiple lives that is being controlled in the airspace by the traffic controllers as well as the safety of the communication navigation and surveillance systems that need to work optimally at all times.

Information communication technology is used to control CNS systems and these need to be operational at all times the tacit and explicit knowledge gained from different sources through different circumstances assist in the knowledge management process. The development IT systems used in an HRO requires technical expertise from users who have dealt with or have been in critical situations before. Other than a traditional IT systems project, IT project in and HRO deals with occurrences and events that are not always readily available.

The systems are continuously in use and users are continually actively aware of external situations that might occur. Potential hazards that might occur on a flight route or location that could affect safety is distributed by an aviation authority, this is known as a Notice to

Airmen (NOTAM). All pilots, controllers and aviation personnel receive NOTAMS when they occur to ensure the safety.

The knowledge in the ANSP is rooted in the organisation and is used when a situation occurs. The study disclosed that employees are willing to share information and that knowledge management is essential.

The study indicated that the organisation keeps up with new technology being a service provider to international stakeholders which implies that technology needs to be abreast or on par. This circle of aviation experts provides the primary domain knowledge that should be accessible for improving safety in the organisation. The study showed that transfer of tacit knowledge is not actioned to harvest when people leave the organisation, but the requirements elicitation process provides different techniques that can be used to extract knowledge that could contribute to knowledge management.

Further to this, the study shows that over 50% of the respondents believe that knowledge from retired employees is lost when they leave. The average age of retirement is 65 years, and the long tenure of employees in the organisation constitutes a wealth of knowledge that could be harvested. The utilisation of KM techniques to capture the knowledge during elicitation could capture the expertise of retired employees, and this could be used in the IS development, success management and mentoring as well as identifying and establishing an expert directory.

Elicitation

The procedures and the ANSP domain is guided by standards and recommended practices. Systems are dependent on aviation regulators to ensure that services rendered are understood and adhered to globally.

The elicitation process will provide system requirements aligned to standard operating procedures, the requirements identified should strive for zero harm and adhere to the recommended standards.

During the elicitation process experiences from operations should be identified and elements previously experienced should be captured and understood. Some of the occurrences might not be captured in the system specification, but the knowledge shared during elicitation could be captured and shared in the organisation or to the greater aviation industry.

To ensure safety decisions are sometimes based on experience. The requirements defined should take into consideration how decisions were made and as well as the cause of the situation. These requirements could form part of the system requirements, or it could contribute to the organisational knowledge or standard operating procedures.

Project Domain

One of the essential elements in an HRO is safety, a safety culture drives the organisation, and this is the product of collective cooperation. One mistake holds the fate of hundreds of lives. The first bullet, identify and capture critical safety elements, demonstrates that safety encapsulates the project domain of an HRO.

The second bullet identifies the lifespan of system. Based on the study, the lifespan of systems at the organisation is fifteen (15) years, the systems are aligned to international standards, and all critical safety elements needs to be identified and captured.

The deployment of a new system runs concurrently with the old system, no trial and error are applied, it is a replica of the current environment with the enhanced functionalities to ensure that performance is always optimised. This simulation includes the functions of the control tower to ensure that real-life scenarios are tested and that no room for error is

left open. Any policies and procedures that deviate from guided policies and procedures are identified and captured. These deviations occur in the standard operating procedures that required individuals to think on their feet and to ensure that safety is the first element.

Known Requirements

In 2014 Malaysia Airlines Flight 370 disappeared, the disappearance of the aircraft was published, and details of the investigation are on-going and are still relevant and the object of discussions. If the aircraft has not disappeared, the world would not have been aware of it, and this would have been one of the multiple airplanes that operate daily across different destinations.

The first bullet describes that the aviation industry focuses on prevention, not reaction, the requirements for an IS is based preventative measures and not on reactive measures. For example, an air traffic controller guides a pilot to take off and land an airplane; this must be done according to the correct procedure and design, understood by global aviation standards. The controller needs to ensure that safety is a top priority when guiding the pilot through airspace.

The second bullet, preoccupation with failures in an HRO, shows that the developed requirements cater for the prevention of failures ensuring safety optimisation in the process. The requirements are known, but the on the ground operations that ensure that safety events are kept to zero requires decisions based on experiences in combination with standard operating procedures and practices.

6.6 Recommendation

Tacit knowledge is unique in its nature, it is costly and difficult to use because it can be difficult to communicate and the possibility of it being reduced to a set of rules systems or elements is implausible. The requirements elicitation process allows for ample opportunity for stakeholders and the analyst to discuss and be involved. During the requirements elicitation process the discussion should not only be on the information

system at hand and the specification, the discussion should also be about the experience that the employees have. After the requirements elicitation is completed, a software specification document is produced, this document is distributed through the organisation there should be a section in the SRS that refers to tacit knowledge to highlight how this was gathered during requirements.

6.7 Limitation of the study

Firstly, other KM processes such as knowledge generation, knowledge distribution and knowledge transfer were not taken into consideration and the research is only restricted to knowledge capturing. Secondly, the focus has only been on the requirements elicitation stage of the SDLC within one HRO in South Africa. Further research is required to generalise the findings.

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Annexure A - Questionnaire

Dear Participant,

You are invited to participate in an academic research study conducted by Tracy-Lee Alison Kotze, MCom Informatics student from the Department Informatics at the University of Pretoria.

The purpose of the study is to address how knowledge can be captured effectively during the elicitation of system requirements to ensure that organisational knowledge can be harvested.

Please note the following:

- This is an anonymous study survey as your name will not appear on the questionnaire. The answers you give will be treated as strictly confidential as you cannot be identified in person based on the answers you give.
- Your participation in this study is very important to us. You may, however, choose not to participate and you may also stop participating at any time without any negative consequences.
- Please answer the questions in the attached questionnaire as completely and honestly as possible. This should not take more than 10 minutes of your time.
- The results of the study will be used for academic purposes only and may be published in an academic journal. We will provide you with a summary of our findings on request.
    - Please contact my study leader, Dr. H. Smuts, Hanlie.Smuts@mtn.com if you have any questions or comments regarding the study.

Regards,

Knowledge management and system requirements	
BIOGRAPHICAL INFORMATION	
I have given consent to participate in this research.	☐
How many years have you been with the organisation?	Choose an item.
Were you ever part of a project team that implemented an Information Technology (IT) System in the organisation?	Choose an item.
Age in Years	Choose an item.
How many IS (IS) / Information Technology (IT) Projects have you been a part of?	Choose an item.
Knowledge management The following statements relates to Knowledge management.	
Employees are willing to share their knowledge.	Choose an item.
Knowledge management is important for the operations function within my department.	Choose an item.
Knowledge management is in a mature stage in the organisation.	Choose an item.
Knowledge from retired employees are lost when they leave the organisation.	Choose an item.
The organisation keeps up with new technology.	Choose an item.
The transfer of tacit knowledge (knowledge in people's head) is important in ensuring that an organisation's most valuable assets do not walk out the door.	Choose an item.
Support for knowledge management understanding is freely available.	Choose an item.

Knowledge management and system requirements

System requirements

There is a standard process of developing system requirements for a new/existing Information System.	Choose an item.
End-Users work closely together during the development of system requirements.	Choose an item.
The development of system requirements involves all relevant parties.	Choose an item.
The outcomes of system requirements are freely available to all employees.	Choose an item.

Knowledge capturing

I am not afraid to share my experiences in my line of work.	Choose an item.
There are situations where decisions depend on my experience rather than a step by step procedure.	Choose an item.
Employee knowledge is captured during the requirements sessions.	Choose an item.
All knowledge captured should be available for all employees.	Choose an item.