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A case study of pre-requirements specification traceability practices in a retail environment

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A case study research report.

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Date : 1 October 2014

TERMS OF REFERENCE

This research was commissioned by the Department of Construction Economics and Management in partial fulfilment of the requirements for the degree of MSc in Project Management.

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ABSTRACT

Purpose: An exploration into the application of pre-requirements specification traceability (pre-RST) practices in Information Systems (IS) projects within a retail setting.

Research Design/methodology: A qualitative study in the interpretivist tradition applied within a single case study setting was selected.

Findings: Awareness and value-perception emerged as the most significant challenge to overcome with recommendations for a well-considered organisational change management programme to address this. The potential impact on the trust relationship amongst requirements practitioners and participants is a factor to be addressed. More readily accessible requirements engineering guides that include pre-RST as a prominent aspect is required to raise awareness levels amongst practitioners.

Practical implications: The research points to a need to raise awareness amongst practitioners through improved and more readily accessible requirements engineering guides that include pre-RST as a prominent aspect. It also highlights what to consider when embarking upon pre-RST, most prominently the need for carefully considered change management programme to tackle value-perception.

Originality/value: Addressing the paucity in case study insights, this research provides an understanding of practice, awareness, value-perception and perceived challenges to pre-RST. Considerations for pre-RST implementation, including careful consideration for the trust relationship amongst requirements practitioners and participants is highlighted.

Limitations: The case study was limited to eleven interviews in the retail industry and therefore may not be generalisable to other industries or general practice.

Keywords: Requirements Traceability, Pre-Requirements Specification Traceability, Retail, Case Study, Information Systems, Project Management, Requirements Management, Requirements Engineering

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Information Systems (IS) projects are inherently complex due to the interwoven and ever-changing nature of technology and the human aspects to IS projects that is so critical to their success (Flowers, 1996; Xia & Lee, 2004). This dynamic context within which IS projects are conceived and evolve, is characterised by constant changes in requirements and project goals, coupled with uncertainty, conflicting assumptions and resulting interpersonal issues (Williams, 1999). Moreover, ever-increasing pressure posed by shorter delivery times (Pinto, 2007), heightened competition, and diverse, dispersed stakeholder structures could render the project requirements, which form the basis for any IS solution, obsolete before they are implemented (Kelly, 2010).

Considering the ever-changing and complex context described above, it is not surprising that software development projects are generally described as having a reputation for failure, despite successful application in various areas (Lyytinen & Robey, 1999; Hartman & Ashrafi, 2002; Young, 2004; Savolainen, Ahonen & Richardson, 2012). Up to 53% of industry investment in technical development projects are reported as suffering cost overruns or failure (Young, 2004).

According to the Project Management Institute (PMI), “poor requirements management is a major cause of project failure, second only to changing organisation priorities” (Project Management Institute, 2014). Various researchers cite requirements quality as one of the leading contributors to poor project success rates (Verner & Evanco, 2005; Berntsson-Svensson & Aurum, 2006; Kappelman, McKeeman & Zhang, 2006; Berenbach, Paulish, Kazmeier & Rudorfer, 2009: 2; Cerpa & Verner, 2009), with Young (2004) considering it “the root cause of the failure of many projects”. Young (2004) further states that “ineffective requirements practices are an industry-wide problem” with Berenbach *et al.* (2009: 2) reporting on recent studies that show “project success is directly tied to requirements quality”. Nevertheless, the value of investing in the requirements process is not commonly understood by the user community and in particular, by the project management community (Young, 2004). In a recent study entitled “The Pulse of the Profession”, the PMI lists requirements management as a critical project management competency (Project

Management Institute, 2014) recommending that if properly implemented and supported, it enables stakeholder expectations to be exceeded, performance to be improved, expected project benefits to be met and tangible business outcomes to be achieved.

Requirements engineering (RE) or requirements management (RM) has therefore emerged as an essential software development practice (Nuseibeh & Easterbrook, 2000; International Institute of Business Analysis, 2009) for the development of effective, good quality software able to meet user expectations (Williams, Hall & Kennedy, 1999). RM includes activities such as requirements definition, change control, traceability (International Institute of Business Analysis, 2009) along with continuous verification and validation of requirements (Kelly, 2010). RE and RM are used synonymously in this paper. The term RM will be used henceforth.

It is now more widely recognised than ever, that the RM process responsible for producing clear, complete, consistent, unambiguous and agreed requirements as the basis for IS development, is conducted in a social setting (Fortune & Peters, 2005; Serrano & Sampaio do Prado Leite, 2011a) with software quality being 'socially defined, socially evaluated, and only accepted within a social setting' (Gotel & Finkelstein, 1994a: 3). An understanding of the organisational context and rationales behind systems requirements is therefore vital to the success of an IS project (Yu, 1997; Fortune & Peters, 2005). Details about the early phase of RM, its social setting and the contributions and interests of a diverse stakeholder base, is considered valuable information for locating and accessing sources of requirements (Gotel & Finkelstein, 1994b). This information will enable an understanding of the requirements themselves, to analyse impacts of inevitable changes to requirements, and reduce errors or assumptions during systems development (Gotel & Finkelstein, 1995; Pohl, 1996). Various researchers concur that details about the social setting that gave rise to requirements artefacts be made explicit and traceable for this purpose (Gotel & Finkelstein, 1994b; Pohl, 1996; Yu, 1997; Cleland-Huang, Zemont & Lukasik, 2004).

Requirements traceability, a fundamental technique that has emerged as "'an effective bridge that aligns system evolution with changing stakeholder needs" (Jarke, 1998: 32), has been divided into two phases namely ***pre-requirements specification traceability*** which is concerned with the production, derivation and refinement of requirements, and ***post-***

requirements specification traceability which is concerned with the deployment, allocation and use of requirements (Gotel & Finkelstein, 1994b). The former will be the subject of this research report.

Background to the Research Problem

Requirements traceability (RT) identifies and documents the lineage of each requirement, including its backward traceability (derivation), its forward traceability (allocation), and its relationship to other requirements (International Institute of Business Analysis, 2009). Positioned as a critical requirements practice in the development, maintenance and evolution of high quality software (Stepanian, 2004), requirements traceability strives to provide a visible thread that binds the originating project goals and requirements to the delivered products.

Gotel & Finkelstein (1994b's) empirical research into the 'requirements traceability problem' is widely regarded as a seminal work in the field of RT. This research led to a distinction between pre-requirements specification traceability (pre-RST) and post-requirements specification traceability (post-RST) as two integrated yet distinctly different aspects to the traceability problem, each with its own purpose and challenges (Gotel & Finkelstein, 1994b). Pre-RST refers to those aspects of a requirement's life prior to its inclusion in the requirements specification (RS) and post-RST refers to those aspects of a requirement's life that result from inclusion in the RS as illustrated in Figure 1 (Gotel & Finkelstein, 1994b; Pinheiro, 2004).

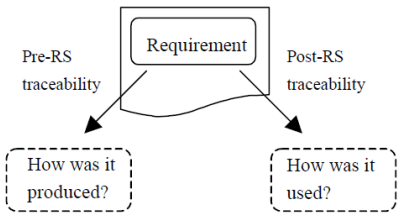

Figure 1: Pre-RS and Post-RS traceability (Pinheiro, 2004: 94)

Consistent change integration is one of the most significant benefits of RT (Pohl, 1996), yet remains elusive given the inability to precisely capture and represent the effects of each

change. This has been cited as a major contributor to the current history of IS failure (Glass, 2002). Traceability may also be legally mandated in the case of critical systems to demonstrate that each requirement has been implemented and that no additional or untraceable code exists, a practice termed “gold plating” (Regan, McCaffery, McDaid & Flood, 2012).

Pre-RST aims to trace the socio-political context from which the requirements emerge and the stakeholder contributions, rationales, assumptions, arguments and decisions relative to a specific requirement (Jarke, 1998; Castro-Herrera, 2007: 11). In addition to the benefits above, pre-RST facilitates the re-opening of previously closed specifications, tracing back to sources of requirements, and possible re-working of a specification in a forward direction (Stepanian, 2004). This is a fundamental benefit considering that records of those involved in requirements production typically become unstructured, unwieldy and inaccessible as projects progress (Gotel & Finkelstein, 1997). Commitment to requirements and commitment among participants becomes fragmented over time and requirements become divorced from those involved in their definition and refinement, resulting in queries being handled by those not best positioned to do so (Gotel & Finkelstein, 1997). A further benefit of pre-RST is the support of system validation performed against requirements through a much needed ability to trace back to source needs (Ravichandar, Arthur & Pérez-Quiñones, 2007).

In research involving more than 100 software development and maintenance practitioners, Gotel & Finkelstein (1994b) reported that most problems attributed to poor RT are due to inadequate pre-RST. Pre-RST problems have persisted in literature over the last 20 years and remain relevant today (Gotel & Finkelstein, 1997; Serrano & Sampaio do Prado Leite, 2011a; Gotel, Cleland-Huang, Huffman Hayes, Zisman, Perez-Egyed, Grünbacher, Dekhtyar, Antoniol, Maletic & Mäder, 2012b). The inability to locate and access the sources of requirements and pre-RS work featured as the most common problem in their investigations, which in turn was reported to lead to further project related issues such as outdated requirements specifications that evolve without input from those originally responsible or the ability to regain the original context. Implications include unproductive conflict resolution, decision making and negotiation due to inability to track essential parties

to such discussions, as well as lack of commitment, accountability and collaboration on teams (Gotel & Finkelstein, 1994b).

Evident from the implications cited above, a range of project management issues arise in the absence of pre-RST. Most research and support has been geared towards post-RST whereas pre-RST remains poorly understood and lacking in tool support despite its accounting for most traceability problems (Finkelstein, 1991; Naqvi & Hyder, 2007; Ravichandar *et al.*, 2007). Furthermore, the results of traceability have been suggested as being less productive than desired if traceability efforts do not involve identification and initiation from the starting point (Sampaio do Prado Leite & Oliveira, 1995).

Despite the advances in research, processes and tools, successful and cost-effective traceability implementations across both industry and government projects remains elusive (Panis & Pokrzywa, 2007). Information about requirements production remains lacking, unreliable, inadequately described and maintained (Gotel & Finkelstein, 1997). Cleland-Huang (2011) reports that the majority of projects fail to use traceability effectively to support the project goals and requirements, including complex and safety-critical projects. Such "universal failure" is broadly attributed to challenges associated with enabling tools and techniques, primarily requirements traceability matrices, and the perception of many developers that effort of establishing traceability exceeds the benefits it returns (Gotel *et al.*, 2012b). RT remains costly and complicated without any guarantees of completeness or correctness (Panis & Pokrzywa, 2007). Neither automated nor manually generated links can therefore be fully trusted (Panis & Pokrzywa, 2007).

The research community continues to grapple with the challenges of traceability, especially between requirements and their source needs (Ravichandar *et al.*, 2007). A fundamental challenge remains the perception about value and benefits of RT, which can undermine any traceability efforts (Gotel, 2008b). Advances in research and practice remain difficult without case study insights into coverage of pre-RST practice which, at present, is a critical research gap that has been raised by the research community (Gotel, Cleland-Huang, Hayes, Zisman, Egyed, Grunbacher & Antoniol, 2012a). An explicit appeal has been made for

updated case study research into traceability practice in organisations and industries that have been under-represented or neglected in research to date (Gotel *et al.*, 2012a).

Research Problem Area

The problem focus area examined in this study is stated as:

Pre-RST can contribute positively to improved software quality and project success. However, pre-RST is not practiced due to limited awareness and value-perception. Furthermore, challenges as perceived by industry are not known due to a lack in case study insights.

Research Questions

The specific research questions addressed are:

1. *What is the level of awareness and value-perception of pre-RST amongst requirements practitioners and participants*?*
2. *What are the challenges to be addressed for the successful implementation of pre-RST?*

*Requirements practitioners refer to those responsible for eliciting and structuring project requirements (typically business analysts) whereas requirements participants refer to those that contribute requirements.

Research Aim

The aim of this research is to:

Establish the level of awareness and value-perception amongst requirements practitioners and determine considerations for successful implementation.

Research Proposition

The research proposition tested in this study is stated as:

The benefits pre-RST has to offer are not drawn upon due to limited awareness or value-perception of this requirements management technique amongst requirements practitioners or participants.

Research Objectives

The research objectives of this study are to:

1. Investigate both formal and informal pre-RST **practices** employed within a retail IS project setting.
2. Determine the level of **awareness** of the concept of pre-RST amongst requirements practitioners and participants within a retail IS project setting.
3. Gain insights into **perceptions** from requirements practitioners and participants regarding the value of pre-RST practices within a retail IS project setting.
4. Gain insight into **challenges** to be addressed when considering pre-RST, as perceived by requirements practitioners and participants within a retail IS project setting.

Significance of the Research

The intended contribution of this study is to fill the current gap in case study insights into pre-requirements specification traceability practices and perceptions in organisations where traceability has not been mandated. An explicit call for current case study insights was made by the research community to researchers recently as it was found to be difficult to make claims about current coverage of the practice or outstanding problems in the absence of such insights (Gotel *et al.*, 2012a). The study serves as an opportunity to close the gap between research and practice by investigating practical concerns related to requirements management and the potential pre-RST offers.

The findings of this research, although not generalisable, include new insights and confirmation of existing knowledge of practice. The research presents levels of awareness and value-perception amongst practitioners; and challenges to be considered if implementing pre-RST. Moreover, this research contributes to the overall empirical research base on pre-RST to assist in the advancement of underlying theory.

Chapter Layout

The research report will be structured as follows:

Chapter 1 introduces the research study and provides the background to research. This includes an outline of the research problem, research questions, proposition and a background to the context within which research has been conducted.

Chapter 2 includes a literature review, presenting research conducted on the topic of pre-requirements specification traceability and the theoretical basis underpinning this research study.

Chapter 3 includes the research methodology and the specific methods to be actioned in the course of data collection and analysis.

Chapter 4 presents the research findings and an interpretive discussion of the research findings and implications.

Chapter 5 presents a summary of the study along with recommendations for further research and for practice.

Conclusion

Various benefits, processes and tools have been presented in literature to support the practice of pre-RST. Requirements practices "appear obvious", namely to understand requirements, manage changes to requirements and establish traceability, yet these are the areas that tend to cause projects to fail (Jonasson, 2008: 23). Consistent and disciplined application and performance of these processes offers significant benefits to projects (Jonasson, 2008).

Research into RT spans a twenty year history; however challenges in achieving cost-effective pre-RST remains widespread along with the implications this has on the success and quality of IS projects. Morris (2010) urges researchers to remain close to practitioners and thereby ensure that research contributions move closer to the problems that practitioners face from the perspective and needs of those who are trying to manage organisations towards

successful outcomes. Moreover, advances in research and practice are stunted by a lack of updated case study insights into organisational contexts that have previously been neglected in research where RT is not mandated. This research study aims to explore current practices and perceptions concerning pre-RST so as to inform further research and practice.

CHAPTER 2: LITERATURE REVIEW

Introduction

Information systems have become an indispensable, pervasive enabler and contributor to the financial success of most organisations. Reports and case studies of poor project performance, however, abound and have not inspired confidence in the IS industry's ability to routinely deliver successful implementations. Software development projects are described as having a reputation for failure, despite successful application in various areas (Lyytinen & Robey, 1999; Hartman & Ashrafi, 2002; Young, 2004; Savolainen *et al.*, 2012). Up to 53% of industry investment in technical development projects are reported as suffering cost overruns or failure (Young, 2004).

Moreover, it is questioned whether sufficient lessons are available to ensure success in future software development projects (Savolainen *et al.*, 2012 citing Cerpa & Verna, 2009). Some researchers suggest that causes of project failure are either covered up or ignored in IS projects and therefore it is not surprising that the IS industry keeps repeating the same mistakes (Lyytinen & Robey, 1999; Hartman & Ashrafi, 2002 citing Johnston, 1995). When considering in-house software development, Verner & Evanco (2005) report that even less is known about project failures as it is unlikely to receive the same attention.

Nevertheless, in a review of extant literature, the most commonly reported causes of such widespread software project failure are of a behavioural, management or organisational nature and usually not due to technical reasons (Yu, 1997; Hartman & Ashrafi, 2002; Fortune & Peters, 2005).

Requirements quality, one such non-technical failure factor, is regarded as one of the leading contributors to poor project success rates (Verner & Evanco, 2005; Berntsson-Svensson & Aurum, 2006; Kappelman *et al.*, 2006; Berenbach *et al.*, 2009; Cerpa & Verner, 2009) with Young (2004) considering it "the root cause of the failure of many projects". Young (2004) further states that "ineffective requirements practices are an industry-wide problem". Requirements management includes activities such as requirements definition,

change control, traceability (International Institute of Business Analysis, 2009) along with continuous verification and validation of requirements (Kelly, 2010).

Studies such as that conducted by Berntsson-Svensson & Aurum (2006) emphasise the importance of requirements management practices whilst the CHAOS report attributes half of the factors associated with project or product success as being requirements related (Charette, 2005; Berenbach *et al.*, 2009). Unstable requirements combined with an inability to deal with requirements effectively have been cited as amongst the most common causes of project failure (Young, 2004; Cerpa & Verner, 2009). Young (2004) estimates the industry average investment in the requirements process as an inadequate 2% to 3% of the total project cost. Research from the United States National Aeronautics and Space Administration (NASA) claims that projects that expended the industry average investment in the requirements process experienced an 80% to 200% cost overrun while overruns ranged from 0% to 50% if an 8% to 14% investment was made. Nevertheless, the value of investing in the requirements process is not commonly understood by the user community and in particular, by the project management community (Young, 2004).

A recent study conducted by the PMI (Project Management Institute, 2014), reveals that only 49% of organisations have the resources in place to manage requirements properly; 53% fail to use a formal process to validate requirements; and only 33% state that their leadership values requirements management as a critical competency for projects and strategic initiatives. The PMI has therefore recommended a focus on "culture, people and processes that support effective requirements management" as a means of reversing this trend (Project Management Institute, 2015). The PMI has furthermore committed to addressing project related issues associated with requirements by releasing a Practice Guide on Business Analysis (Project Management Institute, 2015). This practice guide features RT prominently as an essential business analysis practice and "useful practice to integrate into PMI foundational standards" (Project Management Institute, 2014).

Research by Hartman & Ashrafi (2002) into project failure reveals that little or no alignment exists amongst stakeholders on overarching project drivers. Moreover, inconsistencies in linking key result areas to business strategy are reported as well as in the dynamics of change over the project lifecycle (Hartman & Ashrafi, 2002). Such gaps in tracing between

high level imperatives such as the vision and project success criteria permeate projects to requirements definition which introduces the risk of delivering in a manner disconnected from business or stakeholders needs. A lack of requirements traceability, a key aspect to RM, has been identified as a major contributing factor in project overruns and failures (Gotel & Finkelstein, 1994b; Cleland-Huang, 2005; Borg, Runeson & Ardö, 2014). Inappropriate decision making and inconsistency in management style and focus are reported as some of the implications of a lack of traceability and misalignment amongst stakeholders (Hartman & Ashrafi, 2002).

Software quality, considered as "socially defined, socially evaluated, and only accepted within a social setting" (Gotel & Finkelstein, 1994a: 3), is inextricably linked to the quality of the requirements management process. Details about the early phase of requirements management (RM), its social setting and the contributions and interests of a diverse stakeholder base, is therefore considered valuable information to enable an understanding of the requirements themselves, to analyse impacts of inevitable changes to requirements, and reduce errors or assumptions during systems development (Gotel & Finkelstein, 1995; Pohl, 1996). An understanding of the organisational context and rationales behind systems requirements is therefore vital to the success of an IS project (Yu, 1997; Fortune & Peters, 2005). Various researchers concur that details about the social setting that gave rise to requirements artefacts be made explicit and traceable for this purpose (Gotel & Finkelstein, 1994b; Sampaio do Prado Leite & Oliveira, 1995; Pohl, 1996; Yu, 1997; Cleland-Huang *et al.*, 2004; Liang, Avgeriou, He & Xu, 2010).

The practice of requirements traceability, an essential element of RM (Gotel & Finkelstein, 1994b; International Institute of Business Analysis, 2009), that aims to safeguard the integrity and relevance of requirements, has therefore been selected as the area of focus for this research paper, and more specifically, the earlier requirements phase of pre-requirements specification traceability.

This chapter continues with a brief background to requirements traceability and its contribution to project success. Frequently cited definitions and the various modes and aspects of traceability within the context of requirements management are discussed. Benefits, motivations and challenges associated with the practice of requirements

traceability are then explored. Traceability models that focus on the early phase of requirements traceability, namely pre-requirements specification traceability (pre-RST), will be presented as well as recommendations from the literature to overcome common pre-RST challenges and enable successful implementation and usage.

Background to Requirements Traceability

The concept and practice of requirements traceability first gained recognition in a 1968 North Atlantic Treaty Organisation (NATO) working conference where participants highlighted the need to be able to ensure that a system being developed reliably reflects its design (Gotel, Cleland-Huang, Huffman Hayes, Zisman, Egyed, Grünbacher, Dekhtyar, Antoniol, Maletic & Mäder, 2012c). This conference praised efforts to emphasise building in explicit traces of the design process into the system being designed as a means to achieve such integrity between the design and eventual solution (Gotel *et al.*, 2012c).

Requirements traceability has since been positioned as a critical requirements practice in the development, maintenance and evolution of high quality software (Ramesh & Edwards, 1993; Gotel & Finkelstein, 1994b; Pohl, 1996; Ramesh & Jarke, 2001; Pinheiro, 2004; Stepanian, 2004; Bashir & Qadir, 2006; Jureta & Faulkner, 2007; Ravichandar *et al.*, 2007; International Institute of Business Analysis, 2009; Dubois, Peraldi-Frati & Lakhal, 2010). It strives to provide a visible thread that binds the originating project goals and requirements to the delivered products. Moreover, requirements traceability is considered "an effective bridge that aligns system evolution with changing stakeholder needs" (Jarke, 1998: 32), providing critical support for system development and evolution (Tang, Jin & Han, 2007). Requirements traceability (RT), in its quest to enable alignment between project goals, changing stakeholder needs, requirements and resultant products, therefore involves identifying and documenting the lineage of each requirement, including its backward traceability (derivation), its forward traceability (allocation), and its relationship to other requirements (International Institute of Business Analysis, 2009). An investment in traceability, as envisaged in the 1968 conference, is therefore considered an investment in ensuring stakeholder needs and expectations are met.

Requirements or conditions inevitably change or evolve over the course of a systems lifespan. During this period, many decisions and compromises are made that affect the components of a system or related requirements (Ramesh & Edwards, 1993). It is therefore essential to be able to trace to, from and between requirements, their origins, and design and solution components to ensure changes have been addressed and that the system meets the current set of requirements.

Definitions

The Software Engineering Institute (Stepanian, 2004) defines RT according to the questions it helps stakeholders address: "Where is a requirement implemented?", "Is a particular requirement necessary?", "Are all the requirements accounted for?", "Have we 'gold plated' the product?" (*i.e.* no additional code is written that does not trace to a requirement and no requirement is written that does not trace to a business need, user need or standard (Regan *et al.*, 2012), and "Are we done yet?". The ability to answer these questions is critical to developing quality software and meeting stakeholder needs, hence traceability plays a vital role in improving project delivery.

Gotel & Finkelstein (1994b: 94's) empirical research into the 'requirements traceability problem' is widely regarded as a seminal work in the field of RT (Dubois *et al.*, 2010; Cleland-Huang, 2011; Mader & Egyed, 2012; Regan *et al.*, 2012). In this research, the following, widely-adopted and popular definition of requirements traceability was proposed (Gotel & Finkelstein, 1994b: 97):

> *"The ability to describe and follow the life of a requirement, in both a forwards and backwards direction (i.e. from its origins, through its development and specification, to its subsequent deployment and use, and through all periods of on-going refinement and iteration in any of these phases)."*

In their review of traceability research literature, Bashir & Qadir (2006) ranked this definition as more precise than others, but criticised it for omitting inter-requirements and inter-artefact traceability. Other definitions have been criticised for ignoring traceability between requirements and their origin such as the definition offered by, "*the ability to*

relate requirements specifications with other artefacts created in the development life-cycle of a software system" (Bashir & Qadir, 2006, citing Spanoudakis, 2002). The International Institute of Business Analysis (2009: 67) views the role of traceability as creating and maintaining relationships between business objectives, requirements, other team deliverables, and solution components. It is evident that the IIBA definition also ignores the link between requirements and their origin.

Bashir & Qadir (2006) caution that deficiencies in definitions as highlighted above may cause problems for software systems, leaving critical questions unanswered such as: how requirements link to each other; how requirements link to other artefacts such as design rationale; or what type of users are affected by a requirement. The need for a definition encompassing all aspects of traceability so as to clearly delineate scope and coverage has been recommended (Bashir & Qadir, 2006). Traceability ***scope*** may be limited to software requirements or extend to the broader system whereas traceability ***coverage*** refers to the extent of directionality, namely origin to requirements; requirements to requirements; requirements to other artefacts; or other artefacts to other artefacts (Bashir & Qadir, 2006).

Pinheiro (2004's) model, as illustrated in Figure 2 offers a comprehensive view of the various modes of traceability relative to the requirements specification. The shortcomings in existing traceability definitions, as highlighted by Bashir & Qadir (2006), is largely addressed by this model although its focus is on traceability relative to requirements and hence excludes “other artefact to other artefact” traceability coverage.

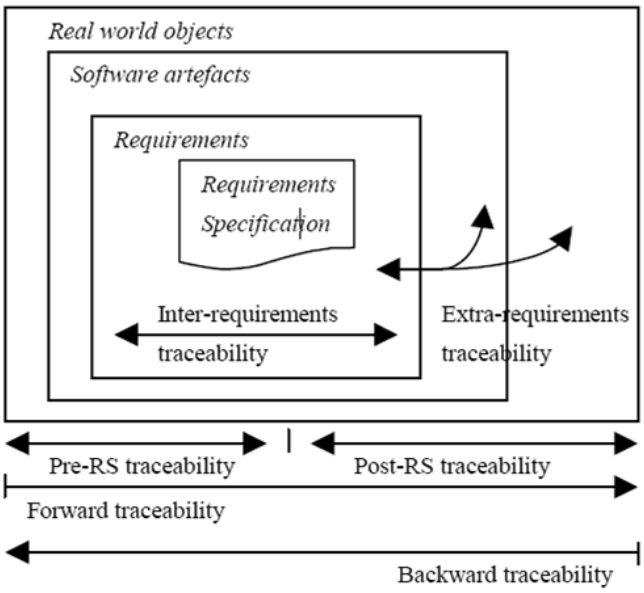

Figure 2: Traceability Modes (Pinheiro, 2004:91)

Pinheiro (2004) argues that traceability may be both bi-directional and inter-connected. The model (Figure 2) illustrates the overlapping modes of traceability, namely inter and extra requirements traceability, forward and backward traceability, and pre-requirements specification and post-requirements specification traceability. Inter-requirements traceability refers to the links between requirements whereas extra-requirements traceability traces relationships between requirements and other artefacts (Pinheiro, 2004). Forward traceability traces a requirement from its origins to its design or programme code with backward traceability tracing a requirement from the solution to its source (Ravichandar *et al.*, 2007). Forward and backward traceability have been split into further traces, namely forward to the requirement (FTR), forward from the requirement (FFR), backward from the requirement to its source (BFR), and backward to the requirement (BTR) traceability as illustrated in Figure 3 below (Naqvi & Hyder, 2007).

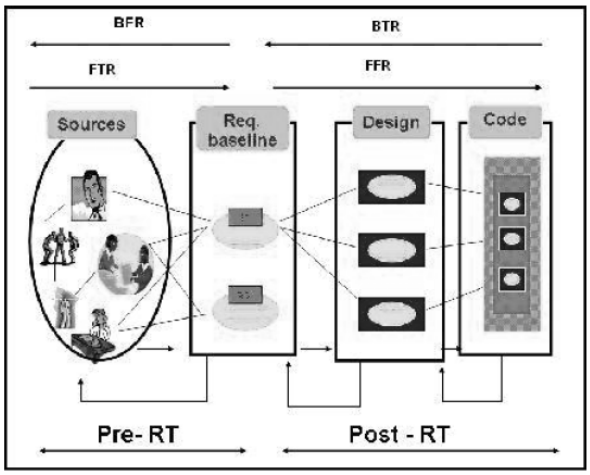

Figure 3: Requirement Traceability Modes (Naqvi & Hyder, 2007)

Pre-requirements specification traceability and post-requirements specification traceability will be discussed in more detail as these are considered two core aspects of the traceability problem (Gotel & Finkelstein, 1994b).

Pre- and Post-Requirements Specification Traceability

Regan *et al.* (2012) simplify the concept of a "trace" as comprising a source artefact, a target artefact and the link between them. Traceability is the ability to establish and use these traces (Regan *et al.*, 2012). Traceability practice dictates that "*in order to follow (i.e. to trace) the life of a requirement, you have to describe it"* (Pinheiro, 2004: 92), which necessitates an explicit record of the evolution of a requirement and its inter-relationships. In describing such an explicit record, a distinction has been drawn between early phase requirements production (or derivation) and the latter process requirements deployment (or allocation) (Finkelstein, 1991; Gotel & Finkelstein, 1994b; Pinheiro, 2004; International Institute of Business Analysis, 2009). Pre-requirements specification traceability (pre-RST) and post-requirements specification traceability (post-RST) emerged as two integrated yet distinctly different aspects to the traceability problem, each with its own purpose, attributes and challenges (Gotel & Finkelstein, 1994b) (Refer Figure 4). The definitions proposed by Gotel & Finkelstein (1994b: 97) remain the popular source quoted in research:

- ***Pre-RST*** *refers to those aspects of a requirement's life prior to its inclusion in the requirements specification (RS)*

- ***Post-RST*** *refers to those aspects of a requirement's life that result from inclusion in the requirements specification (RS)*

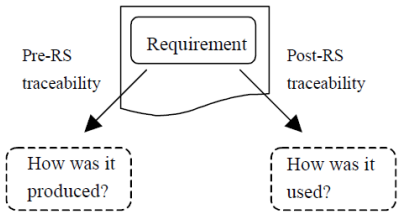

Figure 4: Pre-RS and Post-RS traceability (Pinheiro, 2004: 94)

The requirements specification is considered a means of communication among stakeholders (Wieringa, 1995) and "the authority upon which architectural design and software implementation decisions are made" (Faily, Lyle, Paul, Atzeni, Blomme, Desruelle & Bangalore, 2012). Jonasson (2008: 271) refers to the requirements specification as the primary tool for structuring requirements gathering activities and obtaining approvals. The two parts to the traceability problem as per Gotel & Finkelstein (1994b's) seminal analysis has therefore been delineated relative to this pivotal artefact.

The requirements specification is used to reach agreement between the customer and developer on the functionality, features and non-functional requirements the product should deliver; to derive customer acceptance tests for the product; to partition the product development process across a team of developers; and to correct errors and agree changes in the product (Faily *et al.*, 2012). Both the source and usage of the contents in the requirements specification is therefore of critical importance in maintaining the thread between stakeholder needs and the final product across a range of stakeholders (e.g. customer, analyst, developer) and processes within the software development lifecycle. The IEEE Guide to Software Requirements Specifications only considers a software requirements specification to be traceable if the origin of each of its requirements is clear and if it facilitates the referencing of each requirement in future development or enhancement documentation (Bashir & Qadir, 2006).

Pre-Requirements Specification Traceability, the bigger challenge

Significant research and support has been geared towards post-RST including automated trace generation and commercial tools (Naqvi & Hyder, 2007). However, pre-RST remains poorly understood and lacking in tool support despite its accounting for most traceability problems (Finkelstein, 1991; Yu, 1997; Stepanian, 2004; Naqvi & Hyder, 2007; Ravichandar *et al.*, 2007). Pre-RST problems have persisted in the literature over the last 20 years and researchers concur that these remain relevant today (Gotel & Finkelstein, 1997; Naqvi & Hyder, 2007; Cleland-Huang, 2011; Serrano & Sampaio do Prado Leite, 2011b; Gotel *et al.*, 2012b) especially considering the increasingly complex nature of IS projects (Flowers, 1996; Xia & Lee, 2004; Panis & Pokrzywa, 2007; Dubois *et al.*, 2010).

Empirical research conducted by Gotel & Finkelstein (1994b) involving more than 100 software development and maintenance practitioners, reported that most problems attributed to poor requirements traceability are due to inadequate pre-RST. The inability to locate and access the sources of requirements (Gotel & Finkelstein, 1994b) and pre-RST work featured as the most common problem in their investigations, which in turn was reported to lead to further project related issues such as outdated requirements specifications that evolve without input from those originally responsible (Gotel & Finkelstein, 1994b) for the ability to regain the original context and discuss pros and cons of a change (Naqvi & Hyder, 2007). Implications include unproductive conflict resolution, decision making and negotiation due to inability to track essential parties to such discussions, as well as lack of shared project-wide commitment, accountability and collaboration on teams (Gotel & Finkelstein, 1994b; Stepanian, 2004). Evident from the implications cited above, a range of project management issues arises in the absence of pre-RST. Research by Ahmad & Ghazali (2007) also found that research subjects perceived pre-RST as more beneficial than post-requirements traceability. Traceability has been credited with assisting in the management of scope, change, risk, time, cost and communication (International Institute of Business Analysis, 2009: 67); reducing requirements creep (Regan *et al.*, 2012); and promoting requirements reuse (Stepanian, 2004).

As RM practices mature, a greater emphasis is being placed on the social context within which software projects are undertaken (Fortune & Peters, 2005; Serrano & Sampaio do Prado Leite, 2011a). People, along with their opinions, goals, decisions and interactions, are

considered the most important factor in the RM process (Liang *et al.*, 2010). Tang *et al.* (2007) argue that contextual information about requirements and design is vital to address needs of stakeholders. Pre-RST is the RM practice that explicates the social context within which requirements are produced, tracing the socio-political context from which the requirements emerge and the evolving stakeholder contributions, rationales, assumptions, arguments and decisions relative to a specific requirement (Jarke, 1998; Castro-Herrera, 2007: 11). Pre-RST therefore examines how facts and artefacts are related to, and influenced by, the social structures from which they arose (Gotel *et al.*, 2012c).

Ravichandar *et al.* (2007) contextualises the role of pre-RST as bridging the chasm between the problem (need) and solution (requirements) space, termed the "complexity gap". They add that current traceability techniques cannot adequately bridge this gap with consequences such as loss of domain knowledge, misinterpreted requirements, misconstrued needs (Ravichandar *et al.*, 2007) and ultimately a poor quality solution.

Value perception

Researchers claim wide-ranging benefits from the implementation of pre-RST practices. These range from improved conflict resolution; improved commitment to, and accountability for requirements; to improving the overall software quality by virtue of an improved thread between requirements and solution (Gotel & Finkelstein, 1994b; Regan *et al.*, 2012). The extent to which these benefits have been realised in industry is, however, questionable due to the limited case study insights into pre-RST (Mader & Egyed, 2012; Regan *et al.*, 2012). Moreover, researchers consistently raise the concern about value-perception as a major stumbling block to successful pre-RST implementation (Arkley & Riddle, 2005; Gotel, 2008b).

The section below provides insight into the value-perception of pre-RST amongst project practitioners, and outlines some of the benefits purported in the literature that, if acknowledged, could tackle the value-perception problem.

RT should be viewed as a strategic priority with commitment and support from key stakeholders for its implementation (Gotel *et al.*, 2012a). Although considered important, RT is currently perceived as a tedious, costly, arduous, complicated and error-prone activity

(Heindl & Biffl, 2005; Panis & Pokrzywa, 2007; Gotel, 2008b; Cleland-Huang, 2011; Regan *et al.*, 2012) without any guarantees of completeness, correctness (Panis & Pokrzywa, 2007) or uniformity in results (Pinheiro, 2004: 110). Ramesh (1998) reported that organisations where RT was valued as a strategic imperative offering opportunities to improve software quality and achieve competitive advantage reaped more benefit from RT efforts than if viewed in a narrower sense as satisfying sponsor requirements or standards compliance.

Furthermore, achieving traceability across the requirement lifecycle is particularly challenging when the requirements themselves are often undervalued or poorly understood by project teams (Faily *et al.*, 2012). Requirements specifications are often considered too abstract by developers or not representative of user expectations by usability professionals (Faily *et al.*, 2012). This negative perception of the usefulness of requirements means that the maintenance of system requirements is considered an unnecessary and cumbersome activity adding comparatively little value (Faily *et al.*, 2012). Research by Panis (2010) reported that the value perception of traceability efforts diminishes once the requirements document is produced. Gotel (2008b) recommends tackling value perception head-on as negative perceptions can cripple all good traceability intentions on a project.

Findings from a case study investigating a pre-RST implementation reported wholesale buy-in to the value of pre-RST, which served as a necessary foundation for the success of the implementation (Ramesh & Edwards, 1993, 1995). Every person in the case organisation, from senior management through to system maintenance personnel, believed that "traceability was needed for the successful completion of a project and that without it, their organisation's success would be in jeopardy" (Ramesh & Edwards, 1993, 1995). In a further study by Ramesh (1998), two distinct groups of traceability practitioners emerged based on how they viewed the value of traceability. These were **low-end** traceability users who viewed traceability "simply as a mandate from project sponsors", whereas **high-end** traceability users viewed traceability as "an important component of a quality systems engineering process" (Ramesh, 1998). Ramesh (1998) found that significantly more value was obtained in organisations classified as high end users with benefits including increased process maturity and lower lifecycle costs.

A list of benefits commonly cited in the literature has been outlined in the section below. Recognition and acknowledgement of these benefits and the value they bring to project success and software quality is imperative for successful introduction of pre-RST (Gotel *et al.*, 2012b).

Consistent change integration: Traceability is required to analyse impacts and consequences of changes (International Institute of Business Analysis, 2009: 67), especially where change is constant and requirements are volatile. Traceability between requirements and related artefacts allows project teams to analyse the impact of changing a requirement on other requirements, or on related artefacts, prior to undertaking such change (Gotel & Finkelstein, 1995, 1997; Stepanian, 2004). Consistent change integration is therefore considered one of the most significant benefits of RT (Pohl, 1996), yet remains elusive given the inability to precisely capture and represent the effects of each change. This has been cited as a major contributor to the current history of IS failure (Glass, 2002).

Commitment and accountability: Commitment to requirements and commitment among participants becomes fragmented over time and requirements become divorced from those involved in their definition and refinement, resulting in queries being handled by those not best positioned to do so (Gotel & Finkelstein, 1997). Pre-RST fosters role accountability and highlights the point in the requirements life at which working arrangements of those involved changed (Stepanian, 2004).

Locating requirements' participants: Analysts often require clarification, validation or further information about requirements at varying points in the requirements lifecycle. This involves significant amounts of time to identify the sources of, and contributors to, requirements, especially given that projects involve a broad and diverse stakeholder base. A costly exercise of re-engineering requirements ensues if such information is not available (Ramesh, 1995). Readily accessible and reliable trace information reduces this overhead, adding accurate reference information, including authors or documenters of requirements (Ravichandar *et al.*, 2007). The context within which requirements were sourced is also relevant to investigations, which pre-RST explicates through recording whether a requirement was sourced through a meeting of stakeholders or from an individual, for example (Stepanian, 2004).

Error and cost reduction: Traceable specifications are reported as reducing production costs through re-use and error avoidance (Pohl, 1996; Regan *et al.*, 2012) as well as providing a source of process cost reduction analysis (Stepanian, 2004) savings from using a lessons learned database of critical issues and rationale traced to requirements offers a competitive advantage when building similar systems (Ramesh, 1998; Regan *et al.*, 2012). By supporting change impact analysis, traceability enables more realistic and comprehensive cost and risk estimation of any change to a system (Regan *et al.*, 2012). Project teams will therefore be able to communicate costs and risk to relevant stakeholders with more confidence if traceability is in place. Ramesh (1995), furthermore, reports that the costs associated with implementing a comprehensive traceability scheme may be justified in terms of better product quality with potentially lower life cycle costs.

Customer relationships: Constant change in requirements means greater customer interaction, which if supported by traceability, presents an opportunity for better management of customer relationships (Regan *et al.*, 2012). Considering the often tenuous link between business and IS departments, Jarke (1998: 33) cites pre-RST as a means to strengthen this vital link.

Reuse and continuity: "What is the ramification, regarding the loss of requirements-related knowledge, if a specific individual or group leaves a project? Who would be the best back-up source of information?" (Gotel & Finkelstein, 1997: 10). Pre-RST offers a means of answering this question, one that arises often due to the rate at which project stakeholders change during the system lifecycle. Furthermore, project teams are increasingly constituted from a geographically dispersed or virtual group. Important information such as the rationale behind decisions or compromises taken during the systems development lifecycle (SDLC) may be lost unless documented and traced to corresponding artefacts and stakeholders (Ghazarian, 2008; Regan *et al.*, 2012). This may result in oversight or omissions when extending systems; wasted time and effort identifying and locating stakeholders and revisiting discussions or issues previously concluded by predecessors; or overturning decisions due to a lack of knowledge or context known to predecessors or unknown team members. In addition, often the reasons a requirement was conceived in the manner

described may need to be investigated and compared to other requirements from the same source (Pinheiro, 2004: 95).

Learning and organisational knowledge creation: Traceability facilitates integrating new people into a project through supporting learning (Ghazarian, 2008; Regan *et al.*, 2012) and organisational knowledge creation (Pohl, 1996). Traceability can offer team members access to the rationale behind decisions or compromises taken during the SDLC and the corresponding requirements and solution components. This benefit extends beyond the project lifecycle into the maintenance phase as team members leave and if not explicitly documented, this information will be lost (Ghazarian, 2008).

Reopen previously closed specifications: In addition to the benefits above, pre-RST facilitates the re-opening of previously closed specifications, tracing back to sources of requirements, and possible re-working of a specification in a forward direction (Stepanian, 2004). The ability to re-examine requirements from their sources and subsequent participants implies a more disciplined manner of emergence and evolution of requirements (Gotel & Finkelstein, 1997). This is a fundamental benefit considering that records of those involved in requirements production typically become unstructured, unwieldy and inaccessible as projects progress (Gotel & Finkelstein, 1997).

Solution validation and acceptance: The primary concern in systems development projects is ensuring that requirements have been met and customers are satisfied (Ramesh & Edwards, 1993), a goal that is becoming increasingly onerous as projects become more complex, intricate and integrated. Benefits obtained from traceability include a means to ensure and validate solution conformance to requirements (Ravichandar *et al.*, 2007; International Institute of Business Analysis, 2009; Regan *et al.*, 2012) and thereby improve solution acceptance (Pohl, 1996). The ability to determining the ultimate source and eventual realisation of a requirement sets the basis for validating the solution (Gotel & Finkelstein, 1995, 1997; Stepanian, 2004).

Agility: With the increasing adoption of Agile approaches to software development, where requirements are typically captured and communicated through informal channels, formal requirements processes are being challenged (Ghazarian, 2008). Nevertheless, researchers

agree that traceability remains a key requirement for high quality software and an enabler in both maintaining the customer focus during the software development process and rapidly assessing the impact of change (Lee, Guadagno & Jia, 2003; Ghazarian, 2008). To keep pace with business demands, software projects have to stay abreast with frequently changing customer goals and needs. It is therefore essential that the voice of the customer is carried through all phases of development, and that design decisions are traceable to the conversations where requirements originated (Lee *et al.*, 2003; Ghazarian, 2008). Pre-RST is therefore considered valuable not only in traditional software development approaches such as the waterfall model, but also in Agile approaches. Existing approaches to pre-RST, however, have been designed for traditional software development with formal requirements processes and would require adjustments to support Agile methods (Ghazarian, 2008).

Contractual obligations: Organisations often rely on external contractors or consulting firms for systems development. In these situations, a systematic means of validating that all requirements have been met by the design and resultant solution is important to determine whether contractual obligations have been satisfied (Ramesh & Edwards, 1993; Ghazarian, 2008). Traceability is therefore useful to maintain consistency between the requirements, design and solution and thereby provide transparency in contract situations.

Legal or regulatory compliance: Traceability may be legally mandated in the case of safety critical systems or where regulatory compliance is mandated (Regan *et al.*, 2012). In these cases, evidence of compliance to standards and delivery against the full requirement set is essential to avoid implications such as product recalls or fines as well as to demonstrate that each requirement has been implemented and that no additional or untraceable code exists, a practice termed “gold plating” (Regan *et al.*, 2012). Bi-directional traceability is required to prove that safety requirements have been met for the relevant authorities to certify systems as safe and ready for implementation (Regan *et al.*, 2012). In other cases, organisations may be motivated by a need to fulfil process quality standards such as the Software Engineering Institute’s Capability Maturity Model Integration (CMMI) requirements (Ramesh, 1995; Ramesh, 1998; Heindl & Biffl, 2005). Additional standards that mandate traceability include: ISO 15504; IEEE recommended practice for software

requirements specifications (std 830-1998); and the IEEE standard for software maintenance (std 1219-1998) (Ghazarian, 2008).

As highlighted above, various benefits are promised through implementing traceability. However, the IIBA warns that these benefits can only be obtained if RT is done correctly and consistently (International Institute of Business Analysis, 2009: 44). Moreover, these benefits are highly dependent on addressing the initial obstacle of value-perception amongst stakeholders when introducing pre-RST.

Challenges

Wieringa (1995) posits that major problems of realising traceability are organisational, not technical (Pinheiro, 2004). Ramesh (1998) concurs that environmental and organisational factors significantly influence adoption and use of traceability, in conjunction with the systems development context. The institutional context and the strategic conduct within an organisation interact over time, impacting the adoption of RT as illustrated in the diagram below (Figure 5). Reactions from key stakeholders are influenced by the institutional context and by systems development policies and practices, which in turn, influences the institutional context over time.

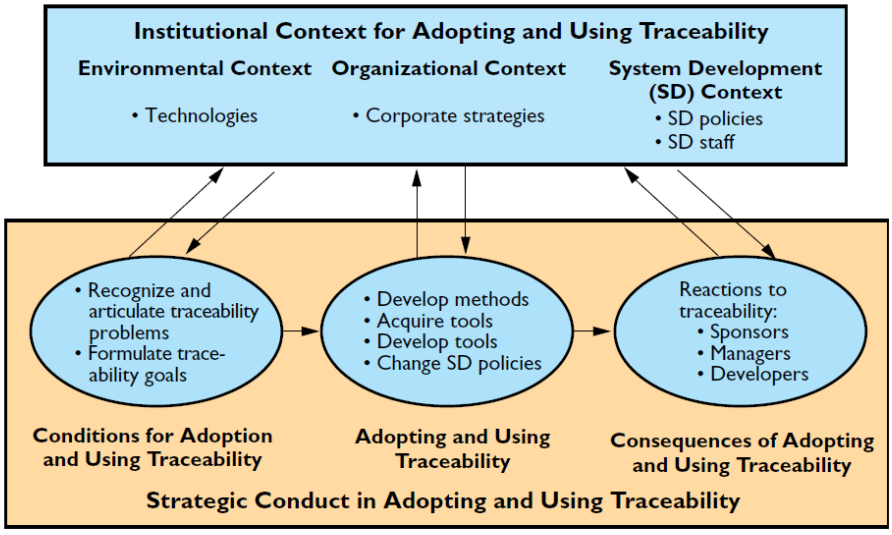

Figure 5: Factors affecting traceability practice (Ramesh, 1998)

Additional barriers to implementing traceability include cost, complexity, trace decay, difficulties tracing non-functional requirements and a lack of implementation guidance (Dubois *et al.*, 2010; Cleland-Huang, 2011; Regan *et al.*, 2012).

The Centre of Excellence in Software Traceability (CoEST, established 2006), a collaborative forum comprising RT researchers and practitioners, summarised the challenges faced by RT into eight core and cross-cutting challenges (Gotel *et al.*, 2012c), with one of these challenges, "ubiquity", considered the ultimate challenge to solve. The eight challenges are to bring about traceability that is purposed, cost-effective, configurable, trusted, scalable, portable, valued and ubiquitous (Gotel *et al.*, 2012b). The section below expands upon these and further challenges that will need to be addressed to achieve the benefits promised by the practice of pre-RST.

Purposed: It is imperative that traceability is "fit for purpose" and stakeholders and their respective needs are identified so as to gear traceability efforts towards meeting expectations from traceability (Ramesh & Edwards, 1993; Gotel, 2008b; Gotel *et al.*, 2012b). To ensure traceability efforts appropriately support the system to be developed, the purpose, goals and potential use of trace information by diverse stakeholders needs to be determined before any traceability efforts commence (Naqvi & Hyder, 2007; Gotel, 2008b; Gotel *et al.*, 2012c: 12). Insufficient attention is given to understanding stakeholder requirements from traceability and validating the extent to which their goals are being satisfied (Gotel, 2008b). Furthermore, Gotel & Finkelstein (1994b) highlighted conflicting perspectives between those parties responsible for establishing traceability and those using it. Expectations from, and problems experienced with, traceability varied amongst practitioners (Gotel & Finkelstein, 1994b).

Cost efficient: The return from implementing traceability should outweigh the costs involved (Gotel *et al.*, 2012b). Automated RT tools are costly and therefore considered deterrents (Regan *et al.*, 2012). Organisations can expect high initial costs and schedule delays whilst contrasting this to the reduction in total lifecycle and maintenance costs due to the development of a higher quality product (Ramesh, 1995; Ramesh, 1998). One case study under-budgeted at twice the normal documentation costs during the initial setup

(Ramesh, 1995). Management, however, viewed this as a once-off cost to be recovered as the organisation benefitted from continued practice in their ongoing systems development efforts. CoEst (2014) recommends planning for the transition of traceability from a development project into its maintenance phase to avoid it eroding. Training can also be time-consuming and costly (Ramesh, 1995).

Configurable: Traceability should be configured to stakeholder needs and responsive enough to accommodate changing stakeholder needs (Gotel *et al.*, 2012b). Traceability efforts including techniques and tools selected or developed should be adapted to the specific project situation, catering for project-specific needs (Jarke, 1998).

Trusted: It is important that traceability information is trusted by all stakeholders from the point of capture through to ongoing maintenance of trace information (Gotel *et al.*, 2012b). The credibility and reliability of traceability links is paramount if used for decision-making (Gotel, 2008b). Whilst automation is strongly recommended (Pinheiro, 2004; Naqvi & Hyder, 2007), Panis & Pokrzywa (2007) caution that regardless of the approach selected, neither automated nor manually generated links can be fully trusted as there is no guarantee that trace information will remain up to date due to difficulties accounting for all possible changes (Naqvi & Hyder, 2007). In addition, Jarke (1998) warns that establishing and maintaining RT could be a politically sensitive endeavour. Concerns may arise amongst stakeholders as to how management will use traceability information and whether it will be used in performance evaluations (Ramesh, 1995).

Portable: Reuse of traceability information across projects, domains, product lines and supporting tools and organisations should be obtained (Gotel *et al.*, 2012b).

Scalable: An RT scheme should be able to support many and varied types of artefacts at different levels of granularity to enable it to scale across the systems lifecycle, organisational and business boundaries (Gotel *et al.*, 2012b). A challenge exists in that manually maintaining trace links is an inefficient approach that does not scale (Heindl & Biffl, 2005; Regan *et al.*, 2012), compounded by the dynamics of software development that

makes maintaining trace links tedious and error-prone (Borg *et al.*, 2014). Despite an increase in availability of automated and semi-automated approaches, cost and complexity of automation are considered deterrents (Regan *et al.*, 2012).

Valued: Value-perception, as discussed earlier in this chapter, is critical to successful implementation. If viewed as a "strategic priority valued by all, where every stakeholder has a role to play and actively discharges his or her responsibilities", RT will be positioned to meet or exceed expectations (Gotel *et al.*, 2012b). Practicality is paramount and should minimise any extra work for the development team, addressing issues likely to cause organisation resistance, and dealing with any contentious political issues caused by keeping potentially sensitive information (Gotel & Finkelstein, 1997).

Additional obstacles to achieving RT include employee inability or reluctance to use traceability tools and technologies (Ramesh, 1998; Cleland-Huang *et al.*, 2004; Cleland-Huang, 2011). Research into training and educational programmes has been identified under the challenge of "valued" traceability by CoEST (Gotel *et al.*, 2012b). Practitioners have claimed difficulty learning and practicing requirements engineering (Ramesh, 1995; Ramesh, 1998; Aoyama, Nakatani & Saito, 2010) compounded by a situation where requirements analyst or engineer are not established professions (Aoyama *et al.*, 2010). Moreover, almost no guidance is available to practitioners for establishing traceability (Mader, Gotel & Philippow, 2009) and organisational education and training are lacking (Aoyama *et al.*, 2010). Aoyama *et al.* (2010) recommend developing a guide for practitioners, a requirements engineering body of knowledge (REBOK).

Ubiquitous: The eighth and "grand challenge" identified by CoEST is obtaining ubiquitous application, defined as "traceability which is always there, without having to think about getting it there". Such ubiquity is achieved when traceability is built into the software development process as a by-product without requiring any explicit or dedicated effort (Gotel, 2008b; Cleland-Huang, 2011; Gotel *et al.*, 2012a) and is "neither consciously established nor sought (Gotel *et al.*, 2012b).

In addition to the 8 grand challenges highlighted by the research undertaken by CoEST, certain additional challenges have been identified in the literature, described below.

Commitment, organisational and project context: Project teams may lack a shared, consistent commitment and ownership (Gotel & Finkelstein, 1994b; Liang *et al.*, 2010). The early requirements elicitation phase in projects involves initial stakeholders who may waver about what the solution should look like with later stakeholders providing a different slant to requirements or integrating multiple requirements statements into one (Liang *et al.*, 2010). Tracing original and subsequent sources becomes increasingly difficult in such project settings, rendering locating sources a time-consuming, unreliable exercise discouraged by management and stakeholders (Gotel & Finkelstein, 1994b). The project organisational structure, social dynamics and politics therefore play an important role in the ability to locate and access sources of requirements.

Clear responsibilities: Unclear lines of responsibility for establishing traceability on a project, and an absence of active champions can result in traceability failing to gain or maintain traction (Ramesh, 1998; Gotel, 2008b). If perceived and treated as an optional extra for team members, with no reward or penalty, traceability may not be taken seriously (Liang *et al.*, 2010). Responsibility for traceability should be distributed amongst several people (Gotel, 2008b) with agreed roles and responsibilities, using a common framework for a project team to work within (Liang *et al.*, 2010). The responsibility for maintaining trace links after the project must also be clarified.

Inconsistency in terminology: Gotel *et al.* (2012c) report that the use of traceability terminology and concepts remains inconsistent amongst researchers and practitioners alike. Recent research also indicates that the term 'traceability' itself is not widely recognised or used in practice despite a level of formal or informal efforts in place to achieve traceability on projects (Gotel *et al.*, 2012a). The lack of standardisation in terminology and definitions is a significant obstacle to achieving successful traceability implementations (Stepanian, 2004; Bashir & Qadir, 2006). Defining and drawing clear boundaries of RT is an essential starting point in addressing current challenges (Gotel & Finkelstein, 1994b).

The nature of requirements: A significant challenge to achieving traceability lies in the nature of the object that is being traced, namely requirements. This is due to difficulties in formalising unstructured information such as user needs and expectations and objectively interpreting and translating these into system requirements (Ravichandar *et al.*, 2007).

Requirements are interdependent, interconnected and may be scattered from a global requirement to multiple local requirements (Nicholas & Steyn, 2008). Moreover, requirements have been differentiated into various classes of requirements (International Institute of Business Analysis, 2009: 5-6), namely business, stakeholder, solution and transition requirements, which imply potentially different sources of requirements and associated processes and practices that RT aims to record.

Project stakeholder structure: Liang *et al.* (2010) reports that pre-RST is complex as projects are comprised of an increasingly larger and more distributed stakeholder base with varying perspectives as to what a business requires. Subtle inter-relationships between requirements; distributed teams; changing technologies and scope creep add to an ever-increasing list of challenges to be addressed (Liang *et al.*, 2010).

Systems development policy: Systems development policies should explicitly mandate active support from management for implementing RT (Ramesh, 1998) along with training and certification to ensure competence in traceability practices (Toranzo Céspedes, Cysneiros Filho, Gómez & Rodríguez Mendoza, 2012). Given the overhead involved, systems development policies should also ensure that traceability is considered upfront while the requirements management approach is being planned, to determine whether and how to trace requirements, what requirements attributes will be maintained, the type of repository to be used, and how change will be handled (International Institute of Business Analysis, 2009: 42). Complexity, number of views of requirements that will be produced, potential impacts from risk, and cost-benefit analysis are to be taken into account (International Institute of Business Analysis, 2009: 42).

Traceability strategy and meta-model: Gotel *et al.* (2012c: 12) advise that traceability needs, type, granularity, available resources, and semantics of trace links may vary from project to project and is therefore best determined specific to a project in a targeted traceability strategy. A targeted traceability strategy is of particular relevance since questions regarding how much traceability is sufficient and what kind of traceability is appropriate for a particular project remains unanswered within the research community (Gotel, 2008b; Cleland-Huang, 2011). Planning and managing a well-formulated traceability strategy, as outlined in Figure 6 below, is therefore a key requirement for effective

traceability (Rempel, Mader & Kuschke, 2013). Furthermore, an underlying meta-model is required as a basis for understanding, traversing and maintaining the traceability information modelled (Gotel & Finkelstein, 1997). The pervasiveness of the use of this concept in practice is unclear though (Gotel, 2008b).

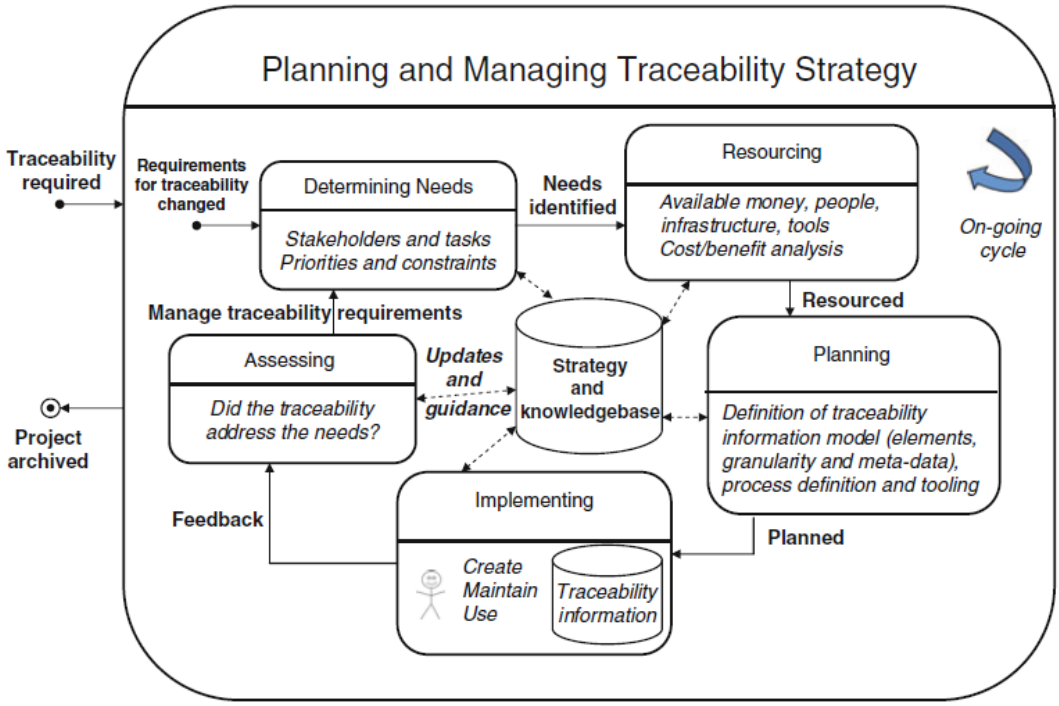

Figure 6: Planning and maintaining a traceability strategy (Gotel *et al.*, 2012c: 12)

The CoEST warns that achieving a revolutionary advance in RT practice is dependent on first understanding and tackling the myriad of underlying challenges. This requires effort from multiple research groups over an extended time period (Cleland-Huang, 2011: 414) and case study insights from industry to inform improved practice (Gotel *et al.*, 2012a). Despite the many challenges to be addressed, the research community agrees that traceability can offer significant benefits in software development (Panis, 2010). A research roadmap has been compiled by CoEST to advance traceability research and practice (Gotel *et al.*, 2012b - Refer Appendix 4).

Current practice

Despite the advances in research, processes and tools, successful and cost-effective traceability implementations across both industry and government projects remain elusive

and challenges considerable (Bashir & Qadir, 2006; Panis & Pokrzywa, 2007; Cleland-Huang, 2011; Gotel *et al.*, 2012c; Regan *et al.*, 2012) RT practice, as reported by Mader *et al.* (2009), "remains poorly documented and, where examined, appears to have limited influence from actual research."

Wide variations in the quality and usefulness of traceability exist with most companies either not implementing it or implementing it in a haphazard manner (Ramesh, 1995; Ramesh, 1998; Cleland-Huang *et al.*, 2004; Cleland-Huang, 2011; Regan *et al.*, 2012). Information about requirements production remains lacking, unreliable, inadequately described and maintained (Gotel & Finkelstein, 1997; Gotel *et al.*, 2012c). Furthermore, recent investigations commissioned by the US Committee for Advancing Software-Intensive Systems Producibility report that "a critical lack of chains of evidence" exists in the software industry, widening the gap between requirements and implementations (Cleland-Huang, 2011). Requirements validation, compliance verification and software assurance cannot be reliably achieved in the absence of such chains of evidence (Cleland-Huang, 2011).

Cleland-Huang (2011) reports that the majority of projects fail to use traceability effectively to support the project goals and requirements, including complex and safety-critical projects. Uniform usage across organisations is not commonplace (Castro-Herrera, 2007), and "not all traces are used and useful" (Gotel *et al.*, 2012a: 4). Such "universal failure" is broadly attributed to challenges associated with enabling tools and techniques and the perception of many developers that the effort of establishing traceability exceeds the benefits it returns (Cleland-Huang *et al.*, 2004; Ravichandar *et al.*, 2007; Gotel *et al.*, 2012b: 344).

The consensus is therefore that pre-RST is either poorly implemented, or not at all. CoEst (2014) warns that traceability is often an afterthought on projects which means that pre-RST artefacts can be missed as traces are only established when needed rather than from the start when project artefacts begin to accumulate.

Naqvi & Hyder (2007) acknowledges that a number of tools and techniques have emerged and been used for RT, each differing in quantity and diversity of trace information, interconnections controlled between information, and the extent to which they support and

maintain RT throughout the project lifecycle. However, in comparison to post-RST, few models or techniques exist to support pre-RST which indicates the need for further research in this area (Yu, 1997; Ravichandar *et al.*, 2007). Bashir & Qadir (2006) evaluated 17 traceability techniques, all of which proved deficient either in scope or coverage of traceability. They recommend combining existing techniques to address shortcomings yet caution against overlap and redundancy when doing so. The need to solve problems of pre-RST and for a simple tool or technique that can be comprehended by all stakeholders has been highlighted by researchers (Naqvi & Hyder, 2007; Ravichandar *et al.*, 2007).

The section below outlines some of the specific tools or techniques reported in the literature as available when implementing pre-RST and aims to provide insight into the practical elements visible within a pre-RST scheme.

Requirements Specifications

Requirements specifications document requirements as natural language text which end up hidden in word processors, spreadsheets or databases (Faily *et al.*, 2012). In certain cases, practice is limited to listing contributors in fields in requirements documents, usually limited to “author” or “owner”, a coarse practice that involves adding more names to the document as changes are made and as such found to be insufficient and misleading (Gotel & Finkelstein, 1995). The use of video, speech and graphics has been suggested for capturing and tracing design rationale and decision-making processes noting that such unstructured information presents challenges when trying to use it (Tang *et al.*, 2007). The systems development lifecycle, which relies on requirements as its driver, could therefore become detached from requirements and their evolution and emergence (Faily *et al.*, 2012).

Requirements Traceability Matrix

A commonly used yet basic and manual technique is the Requirements Traceability Matrix (RTM) (Gotel & Morris, 2011), typically maintained by analysts or developers in a document, spreadsheet, database or requirements management tool (Cleland-Huang, 2006). The RTM aims to link the project scope, requirements and deliverables to ensure these remain consistent with each other when compared with the baseline (Cadle, Paul & Turner, 2010).

The RTM traces relationships between the requirements document and post-requirements artefacts such as design modules, code modules and test cases (Raja & Kamran, 2008: 49). Links are manually constructed, maintained, and analysed by analysts who determine which artefacts to trace and the level of granularity (Cleland-Huang, 2006). An RTM should be bidirectional *i.e.* enabling tracking requirements forwards to the solution and backwards to the business requirement (Cadle *et al.*, 2010). It, however, does not extend as far back as pre-RST and therefore will not provide the ability to locate the sources of requirements. The RTM has therefore been criticised for its inability to address pre-RST. Furthermore, Cleland-Huang (2006) reports that, in practice, many carefully constructed RTM's become inaccurate and incomplete as a system evolves, rendering RTMs as "time-consuming, arduous, and error-prone".

The V-Model

The "V-model" is a widely used systems development model (Goodpasture, 2002) that represents a translation of business needs, requirements and artefacts across the systems development lifecycle to the point that the solution can be validated and verified against requirements specifications. The strength of the V-model lies in its simplicity and its reflection of the translation process that occurs on projects, commencing with a business problem or opportunity embodied in a business case document through to solution. The V-model depicts a means of bridging what Ravichandar *et al.* (2007) termed the "complexity gap" between a business need and the solution, as described earlier in this chapter.

Goodpasture (2002: 51) adapts the "V-model" to represent the translation across various classes of requirements, from higher-level goals into implementation requirements. The thread that develops through this "requirements translation" process (Goodpasture, 2002: 51) converts an envisioned value proposition, as outlined in the business case, into actionable implementation requirements (See Figure 7). The V-model and Goodpasture (2002's) adaptation therefore emphasises traceability between artefacts, with the vision embodied within the business case and the more detailed business requirements documented in the requirements specification. Whilst translation between the business case and business requirements specification is vital, traceability extends beyond this to the

broader social infrastructure involved from the visioning/business case stage (Gotel & Finkelstein, 1994b; Sampaio do Prado Leite & Oliveira, 1995; Castro-Herrera, 2007; Gotel *et al.*, 2012c).

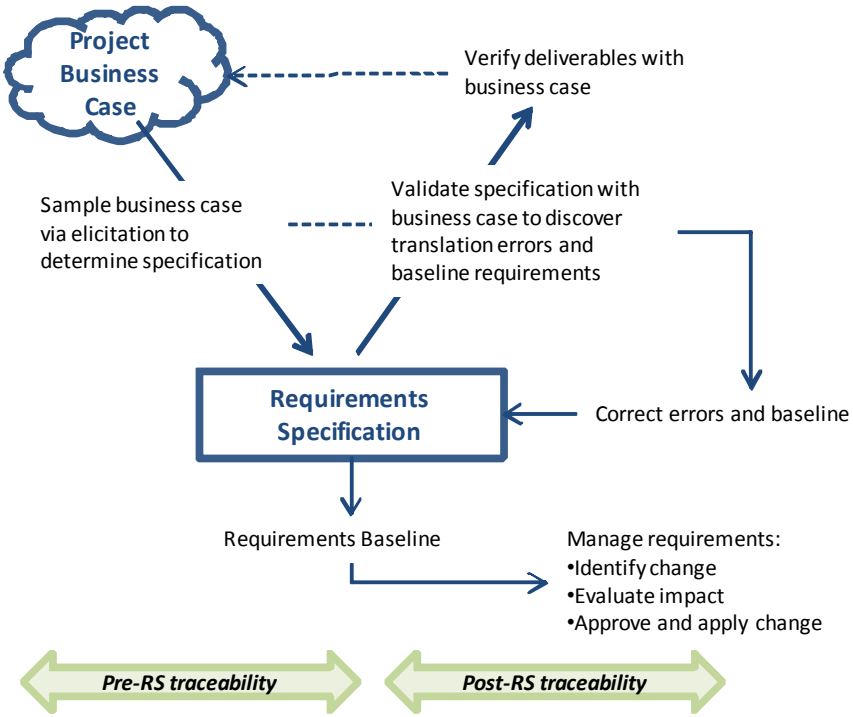

Figure 7: V-model (Goodpasture, 2002), adapted to include pre-RST and post-RST

Contribution Structures

Gotel & Finkelstein (1995) identified the need for maintaining a "detailed and dynamic model" of the relationships amongst contributors involved in requirements production, both individuals and groups; amongst the requirements artefacts generated; and between contributors and contributions (Naqvi & Hyder, 2007). "Contribution structures" emerged as a comprehensive pre-RST scheme to explicate human sources of requirements. It comprises a personnel-based traceability model that outlines the web of relationships among contributors, namely documenters, authors and principal/sponsors of requirements; and artefacts resulting from their contributions (Gotel & Finkelstein, 1997). Gotel & Finkelstein (1997) argue that this enables requirements to become "anchored in the network of people from which they arose".

Described as modelling the social structures underlying requirements elicitation (Naqvi & Hyder, 2007), contribution structures has been regarded by various researchers as the foundation of pre-RST (Jarke, 1998; Serrano & Sampaio do Prado Leite, 2011a; Ingram & Riddle, 2012).

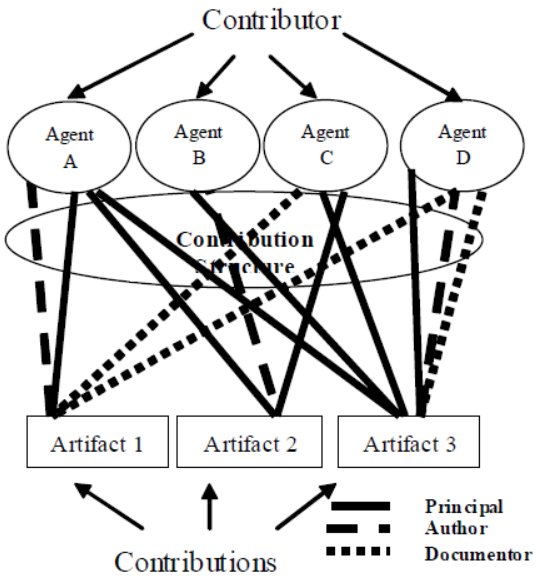

Figure 8: Three contribution layers to organise the contribution structure model (Naqvi & Hyder, 2007)

Jarke (1998: 33) acknowledges that contribution structures underlying requirements are crucial in validating requirements, especially in highly political settings. However, not all information surrounding contributions can be readily obtained or documented, for example tacit knowledge or confidential rationales and where obtained, these may vary in quality due to many factors such as time constraints (Naqvi & Hyder, 2007).

As evident from the roles and relationships to artefacts embodied within the design of the Contribution Structures scheme, it aims to differentiate the various ways in which agents can contribute to requirements artefacts (See Figure 8) thereby supporting role-based traceability analyses (Gotel, 2008a). It allows for modelling contributor relationships in progressively more detail and accounting for various relations within and between requirements artefacts themselves. This includes modelling dependencies or decomposition of requirements into component artefacts thereby enabling contributors and artefacts to co-evolve.

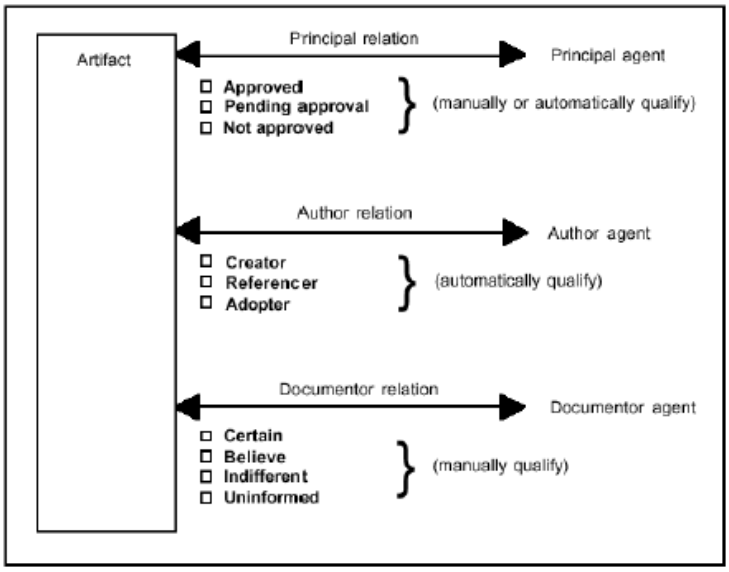

Figure 9: Contribution Formats (Stepanian, 2004)

The contribution structures scheme requires an underlying metamodel as a basis for using the information modelled and for maintenance of the model itself (Gotel & Finkelstein, 1997). The scalability of Contribution Structures to larger industrial purposes along with case studies to evaluate the approach in practice had not been investigated (Gotel & Finkelstein, 1997).

PRO-ART

Arguing that models such as Contribution Structures overlook certain aspects of pre-RST, Pohl (1996) proposed a framework he considered more comprehensive. Pohl's model, PRO-ART (Process and Repository Based Approach to Requirements Traceability), is based on three main contributions, namely (1) a three-dimensional framework for requirements engineering that defines the kind of information to be recorded; (2) a trace-repository for structuring and retrieving trace information; and (3) a tool interoperability approach to enable automated trace capture (Pohl, 1996). The advantages of PRO-ART are reported as lying in recording three dimensions of trace information as depicted in Figure 10 below.

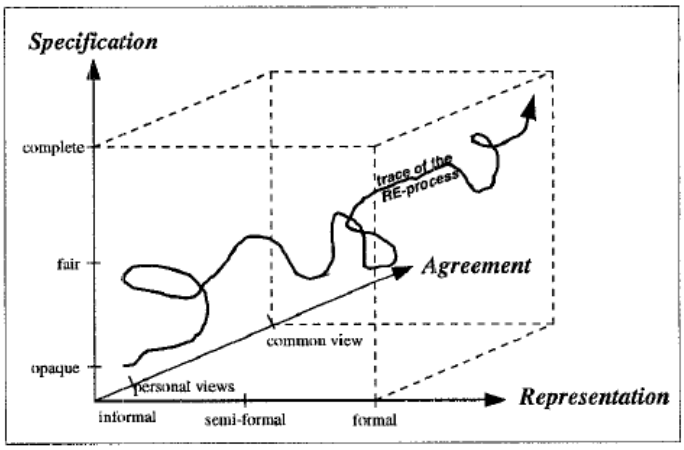

Fig. 2.1 The three dimensions of requirements engineering

Figure 10: The three dimensions of requirements engineering (Pohl, 1996)

The first dimension, the representation dimension, describes the transformation from an informal to a formal specification and executable code. The second dimension, the specification dimension, deals with completeness and coverage of the problem for the purpose of identifying whether all requirements have been captured and whether each known requirement is covered in full. The last dimension, agreement dimension, addresses whether agreement has been reached on the current specification (Pohl, 1996). The PRO-ART model uses an information/process-based approach which Stepanian (2004) argues renders it more comprehensive and robust.

Ramesh and Edwards

The traceability model developed by Ramesh & Edwards (1993, 1995) illustrates the type of information to be captured in a pre-RST scheme.

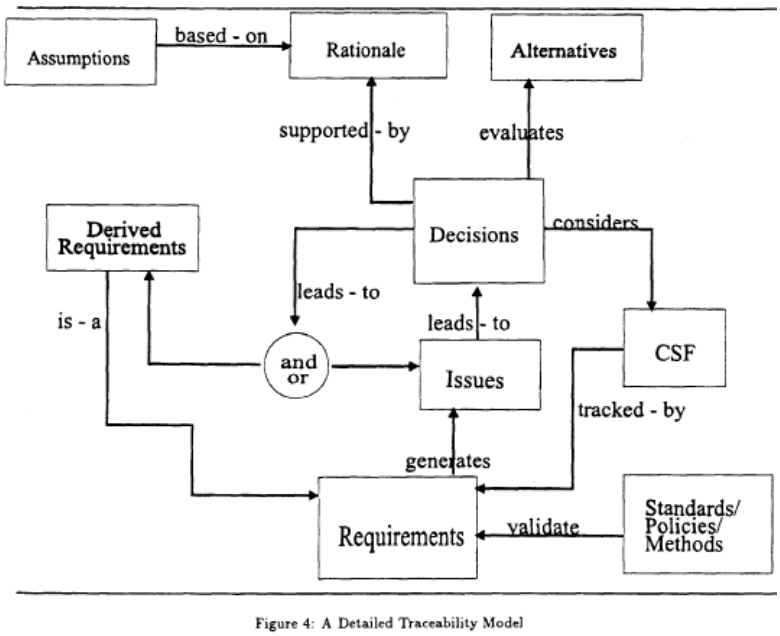

Figure 4: A Detailed Traceability Model

Figure 11: A detailed traceability model (Ramesh & Edwards, 1995)

iTrace

A recent contribution to pre-RST literature includes a pre-RST snapshot concept offered by the iTrace model to complement "i* models". Arguing that it is unlikely for links to be maintained, Serrano & Sampaio do Prado Leite (2011b) proposed recording a separate snapshot model for every iteration of requirements elicitation. This snapshot will accompany the relevant version of the requirements specification. The approach traces requirements engineering artefacts back to social interactions, social interactions' goals, activities, techniques, social networks, information sources, and resources through the use of Rich Pictures, an informal hand-drawn model devised by Monk & Howard (1998). The proposal includes modelling stakeholder arguments on social interactions using an "argumentation framework" as proposed by Jureta & Faulkner (2007) (Serrano & Sampaio do Prado Leite, 2011b: 133). Whenever an i* requirements model is produced, evolves, is analysed or is discarded, an iTrace snapshot model enriched with argumentation should accompany it. The model represents a base layer, an interaction layer and an artefacts layer, as illustrated in Figure 12 below.

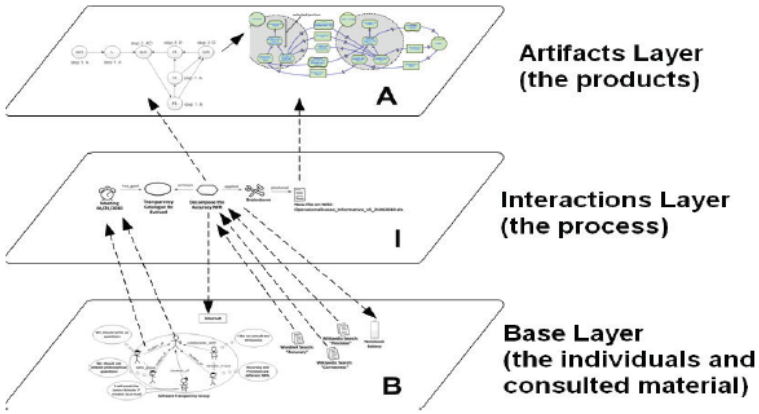

Figure 12: The three layers of iTrace: Base (B), Interactions (I) and Artefacts (A)

Serrano & Sampaio do Prado Leite (2011b) argue that the strength of iTrace models lies in the minimal effort and overhead required to compile and maintain them, overcoming difficulties maintaining traces as requirements engineering artefacts evolve. iTrace models are easily hand-drawn during social interactions with no additional work required after meetings. iTrace models are snapshots accompanying an i* requirements model and do not evolve. If a new i* model evolves, a new iTrace model will be created to trace this evolution. The iTrace model is a recent research contribution and therefore requires further research to evaluate its efficacy.

TraCS

Cleland-Huang *et al.* (2004) proposed an approach to traceability termed Traceability for Complex Systems (TraCS) that combines a heterogeneous set of techniques to be strategically deployed. They believe this will maximise the return-on-investment of the requirements traceability effort. Employing a single technique such as a matrix or tool embedded into a RM package does not offer an optimal solution for diverse requirements (Cleland-Huang *et al.*, 2004). TraCS starts with defining trace strategies at an overall project level for categories of requirements. Links are established strategically to optimize returns of the traceability effort and minimize the risk inherent to software evolution.

Contribution Structures extended with RTM

Naqvi & Hyder (2007) proposed the use of contribution structures in conjunction with an RTM to provide end-to-end coverage thereby integrating a pre-RST and post-RST technique. The means for such integration involves mapping elements of a contribution structure to the elements of an RTM as depicted in the entity relationship diagram below in Figure 13.

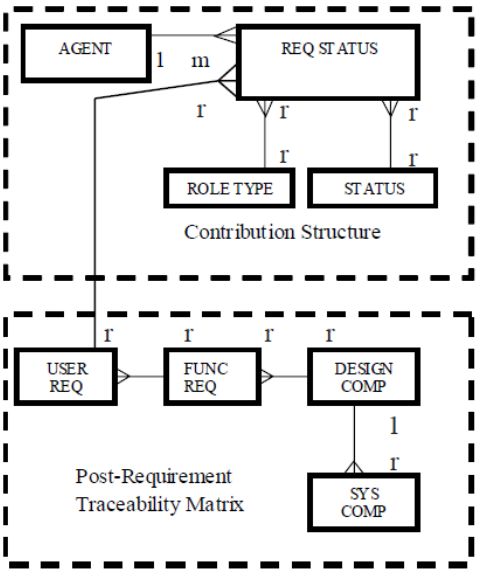

Figure 13: Entity Relationship Diagram (Naqvi & Hyder, 2007)

Whilst this hybrid is more comprehensive, enabling better end-to-end traceability, it fails to improve pre-RST beyond what contribution structures offers.

Whilst various pre-RST models are available to practitioners as outlined above, Gotel & Finkelstein (1994b) warn that adherence to methods, models or guidelines may not produce consistent, reliable results as models are rarely used as intended. Manually provided information will suffer from subjectivity and incompleteness as opinions as to relevance differs, classification schemes are rarely shared and equal commitment to detail is unlikely. Moreover, despite tools and techniques made available for pre-RST implementations, Mader *et al.* (2009) acknowledge that very little is known about current traceability practice, raising questions such as: "Is it widely undertaken and used? Are the problems experienced the same as a decade ago? What, if anything, has changed and where does the research emphasis now need to lie?"

Conclusion

Pre-RST, the practice that explicates the socio-political context within which requirements are produced, is considered a greater yet under-represented area of concern in software development than post-RST, and as such, requires attention from both the research and practitioner communities.

The literature review has framed the context for the research by providing insights into current practice and models, value-perceptions and challenges to implementing pre-RST, and foundational concepts.

It is evident that insufficient information is available on the practice of pre-RST as undertaken in industry. Researchers have highlighted the gap in current case study insights on the topic (Gotel *et al.*, 2012c) and made explicit appeals for updated case study research into traceability practice in organisations and industries that have been under-represented or neglected in research to date (Ravichandar *et al.*, 2007; Gotel *et al.*, 2012a). Problems are often perpetuated due to poor feedback regarding pre-RST best practice (Naqvi & Hyder, 2007).

CHAPTER 3: RESEARCH DESIGN

Introduction

The discussion in Chapter 2 focused on the topic of requirements traceability and more specifically on the lesser researched pre-requirements specification traceability aspect of requirements traceability. Current practice, perceptions and challenges were discussed along with foundational concepts, motivations for and detractors from implementing traceability. This chapter focuses on the methodology underpinning the research which aims to draw out insights into current practice and perceptions amongst practitioners as to the appetite and considerations for pre-RST.

It was noted in the literature review that RM and RT research lacks empirical insights into the phenomenon of pre-RST as practised on projects where pre-RST is not mandated. Researchers have highlighted the gap in current case study insights on the topic (Gotel *et al.*, 2012c) and made explicit appeals for updated case study research into traceability practice in organisations and industries that have been under-represented or neglected in research to date (Ravichandar *et al.*, 2007; Gotel *et al.*, 2012a). In their review of the state of research in the field of requirements engineering, Cheng & Atlee (2007) recommended that researchers partner with practitioners so as to provide researchers with a thorough understanding of the real problems faced by practitioners. The literature review also highlighted that both RM and IS projects are socially rooted endeavours and should therefore be studied in its social context to extract meaning from practical experiences and perceptions.

A qualitative research approach within a single case study has therefore been selected to fill the gap in empirical case study insights. This has been done in a manner that provides the opportunity to draw meaning from exploring practitioner experiences on projects. Insights drawn from this case study research could be useful in informing future research directions, as a thematic analysis will be performed on the data. The section that follows will describe and justify the research method chosen. The data collection technique and data analysis procedure followed is also discussed. The chapter concludes with a discussion on the ethical considerations pertinent to the research and the confidentiality agreement exercised.

Research Methodology

A research methodology relates to the methods, approaches and techniques suitable for conducting empirical research. The research method has been described as a strategy of inquiry that unfolds from the underlying philosophical assumptions to the research design and data collection (Myers, 1997). The research design informs the way data is collected (Myers, 1997) and should therefore be carefully considered before embarking upon the research. Yin (2009) advises researchers to exercise great care when selecting a suitable research method and to ensure the choice is an appropriate fit for the specific study.

Benbasat, Goldstein & Mead (1987) recommend the following four questions be considered in determining an appropriate research strategy:

- Can the phenomenon of interest be studied outside of its natural setting?
- Must the study focus on contemporary events?
- Is control or manipulation of subjects or events necessary?
- Does the phenomenon of interest enjoy an established theoretical base?

Considering the guiding questions above, it is worth noting that the subject of this research study, namely requirements traceability and more specifically pre-requirements specification traceability, is deeply embedded within a socio-political process of requirements management, influenced by many contextual factors (Ramesh, Cao & Baskerville, 2010), human actions and interactions, and therefore cannot be studied outside of its natural setting. It is important that the context is explored. Any control or manipulation of subjects will erode the value or richness of the research, and therefore will not be sought in the current study which seeks to focus on current and contemporary practice, experiences and perceptions. With this in mind and considering the responses to the four questions Benbasat *et al.* (1987) poses, the current study will use a case-based methodology within the broad tradition of interpretivism (Orlikowski & Baroudi, 1991; Gable, 1994; Yin, 1994) which is expanded upon in the section below.

Interpretivism

Interpretivism is considered the best epistemology for studies that aim to "describe, interpret, analyse and understand the social world from the participants' perspective" (Orlikowski & Baroudi, 1991: 15). Moreover, interpretive research is emergent. Checkland & Holwell (1998: 238) recognise that the IS field has "meaning at its core" and therefore advocate interpretivism as an appropriate paradigm for IS research. Interpretive research takes account of the fact that the social world is constructed through meanings (Benbasat *et al.*, 1987; Gable, 1994; Klein & Myers, 1999). Interpretive techniques allow participants to use their own words and images, and to draw on their own concepts and experiences (Glaser & Strauss, 1967). Clearly defined principles and guidelines that can be followed mechanistically are not often prescribed (Klein & Myers, 1999). Interpretive and qualitative studies enable the researcher to understand the phenomenon and the context within which it is practiced as well as the meaning people assign to phenomena (Myers, 1997). Such research strategies that embrace phenomena in context have also been classified as idiographic or ethnographic (Benbasat *et al.*, 1987; Eisenhardt, 1989; Mouton, 2001) .

It is imperative that the research method used follows from the questions to be answered (Punch, 2005: 20). The questions posed in this research study aims to uncover current practice and perceptions related to the process of pre-requirements specification traceability within retail IS projects. A descriptive or exploratory approach has therefore been selected with the intention of presenting a detailed description of exactly what happens in the selected case. Explanatory research is considered superior to descriptive or exploratory research as it provides insight into why or how something happens which allows for predicting or controlling what will happen (Punch, 2005). Descriptive research, in contrast, merely provides insight into what happens. Nevertheless, Punch (2005: 15) points out that explanation requires description and that descriptive research is still considered important as the first step towards explanation. "If we want to know why something happens, it is important to have a very good description of exactly what happens" (Punch, 2005: 15). "It is hard to explain something satisfactorily until you understand just what the something is" (Miles & Huberman, 1994). Descriptive research, for example, is of significant value where careful description of complex social processes helps us understand factors to

concentrate on for later explanatory studies (Punch, 2005). Moreover, a good description often provides clues to explanation (Punch, 2005).

The case study research strategy

Case-study research provides the opportunity "to ask penetrating questions and capture the richness of organisational behaviour" (Gable, 1994), and has been described as "interpretation in context" (Merriam, 2009). Furthermore, Mouton (2001: 173) argues that in-depth case studies provides "high construct validity". The case study research strategy supports empirically examining a phenomenon in its real-life context (Orlikowski & Baroudi, 1991; Yin, 1994) and is therefore appropriate for this specific research study.

The phenomenon of pre-RST aims to explicate the socio-political context within which requirements are produced and should therefore be examined in its settings for it to be properly understood. Practices selected or neglected in an organisation could be influenced by various contextual factors which are best understood through in-depth inquiry rather than quantitative enumeration. An in-depth analysis of a single case study will therefore be undertaken to uncover and explore pre-requirements specification traceability practices employed on IS projects in a retail setting. Practices employed, as well as perceptions, will be investigated to understand and present industry experiences along with the rationale behind selected, neglected or rejected approaches to traceability. The boundaries between the phenomenon and context may not be clearly evident in case studies and the research questions will be more explanatory in nature *i.e.* "how" and "why" questions (Yin, 1994: 13).

Further motivation for the case study approach comes from Franz & Robey (1986) and Benbasat *et al.* (1987) who suggest that IS research is best covered through case research. Situations characterised by "sticky, practice based problems where the experiences of the actors are important and the context of action is critical" are also seen as most appropriately covered through case research (Benbasat *et al.*, 1987: 369). Case studies have the potential to bring about new meaning, to unearth previously unknown variables or relationships leading to rethinking the phenomenon under scrutiny, or to confirm what is known (Merriam, 2009).

Yin (2009) reminds us that case study research has unfortunately not gained widespread recognition as a method of choice potentially due to incorrect perceptions, a lack of trust in the credibility of procedures used by the researcher, and a perceived inability to generalise case study findings to any broader level. A further perception is that case studies are prone to bias from the researcher and unable to sufficiently guard against the researcher finding what was sought (Yin, 2009). Yin (2009) therefore urges researchers to use systematic procedures during data collection and analysis so that findings may be generalised to other situations through analytic (not statistical) generalisation.

Case organisation: Motivation

Researchers have made explicit appeals for updated case study research into traceability practice in industries that have been under-represented or neglected in research to date (Ravichandar *et al.*, 2007; Gotel *et al.*, 2012a) and more specifically in industries where pre-RST is not mandated. The case organisation selected fits these criteria. Furthermore, the organisation can be considered a good representative within its industry, as it is one of the largest retailers in South Africa.

The research was undertaken in a well-established, multi-national, multi-channel, corporate retail chain. The organisation is based in South Africa with a footprint in Southern Africa and aggressive plans for further expansion. The business spans across a broad range of products and locations, servicing a diverse and sizeable market base. The business offering includes groceries, clothing, liquor and pharmaceuticals, amongst other lines of business. Business models include both traditional and online retailing, and a franchise business. Annual turnover was approximately R60billion at the time the research was conducted, with an employee base in excess of 40,000 employees across more than 800 outlets.

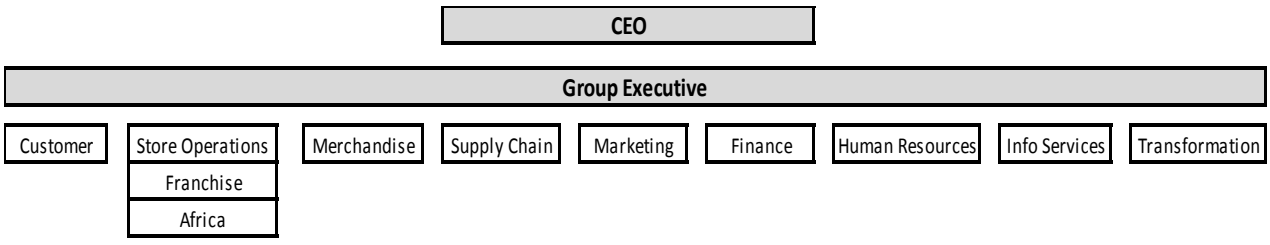

Figure 14: Organogram (Compiled from Case Organisation, 2013)

Projects range from significant business process transformations to system implementations or upgrades; exploring new markets, partnerships, product ranges or channels; real estate expansions and refurbishments; amongst others. Approximately 8 large transformation programmes and 80 projects were underway at the time the research was conducted. This excludes smaller projects undertaken within individual business units.

The amount of change and projects underway combined with a large, diverse stakeholder base therefore makes this a compelling case for understanding how such a complex organisation traces its requirements to the web of contributions and whether a practice such as pre-RST is deemed worthwhile by requirements practitioners. The case is therefore a good representative of its industry and one that encounters the complexities inherent in the requirements management process. Based on the literature review, an organisation that undertakes projects as described should benefit considerably from the practice of pre-RST.

The case organisation represents an environment where IS is not its core business, yet forms a pervasive and essential enabler to both its strategic and operational imperatives. The IS division plays an integral role in the business with its scope extending beyond the delivery of technology into the management of projects from the point of requirements definition through to solution implementation and maintenance. The organisation is completely dependent upon technology and business information systems for its day-to-day operations, management and growth.

A large proportion of projects therefore have a significant IS component. Examples of such IS-intensive projects underway at the time of this research range from replacement of the point-of-sale system in all stores to the expansion of the customer loyalty proposition and its capabilities; upgrading the warehouse management system; introduction of product development and merchandise planning solutions.

Projects range from replacement of the point-of-sale system in all stores to introduction of customer loyalty schemes, transforming its merchandising processes and centralisation of its supply chain operations, to mention a few.

The focus of this research was from the perspective of the in-house IS organisation's support to various business units in defining and delivering against business requirements within these business units.

This case is what Gotel *et al.* (2012a: 2) would consider an "untypical context" for traceability research, as it is not mandated to comply with requirements traceability standards. Although considered "untypical" for traceability research, it is a typical case of a complex requirements development environment and therefore deserves exploration to tease out practices and perceptions from examples beyond the confines of mandated cases.

The selected case organisation is fertile ground for studying the phenomenon of pre-RST and its relevance to such an organisation as reports of levels of success in project delivery and fulfilment of stakeholder expectations vary significantly. Anecdotal input concerning the level of clarity, completeness, commitment and coherence of requirements have been raised whilst the researcher has been in the employ of the organisation. Cases of solutions being developed whilst requirements were either unclear at the outset or evolved without sufficient stakeholder commitment or approval have been raised as concerns. Investigating this case therefore provides an opportunity to understand whether and how pre-RST could offer value to the organisation whilst considering differing degrees of success.

The organisation is currently drafting a set of integrated solution delivery frameworks of which the Business Analysis framework features prominently. Findings from this research study could inform considerations for the frameworks under development.

Sampling Strategy

The interview sample has been selected based on a purposeful sampling technique (Miles & Huberman, 1994) so as to draw insights from practitioners involved in the process of requirements development across different business units. Further sampling considerations were taken into account as recommended by Rempel *et al.* (2013) which included the relevance of the general candidate characteristics; the candidate's potential to generate rich information; and the likelihood of generalising findings from the particular candidate.

For rich insights, contextual information and insight into organisational practices and context, it was decided to interview candidates with an employment history of at least 3 years. This left a small pool of potential candidates as the IS division is predominantly staffed by contractors and consultants, many of whom were relatively new to the organisation. For varied insights, a range of roles involved in the requirements process from different perspectives were sought. For example, roles ranged from business managers or project sponsors who act as requirements providers to business analysts and business partners who elicit, interpret and document business requirements for translation into technical requirements and solution delivery. To assess the extent of variation within the organisation, interviewees were selected from business units that represented different organisational structures (*i.e.* centralised and decentralised) and levels of maturity with respect to project processes. Eleven interviews therefore served as the primary data source for the research which, although limited from which to generalise findings, fits Eisenhardt (1989's) guidelines of a sample of between 4 and 10 for in-depth qualitative case studies.

Research Method and Data Collection

The aim of the research study was to explore pre-RST practices and perceptions amongst practitioners in a Retail IS project setting. The intention was to explicate the level of awareness and practice, albeit informal, within industry, and present the perceptions practitioners hold with respect to perceived value and challenges associated with the implementation of such a practice. The data required to achieve this objective was of a qualitative nature as motivated in the research methodology. However, insights into the level of awareness amongst practitioners with respect to the concept of pre-RST was represented using a quantitative approach, thereby reflecting a mixed method of both quantitative and qualitative data analysis.

The research method applied has unfolded as depicted by Stake (1995's) qualitative research process below (Refer Figure 15).

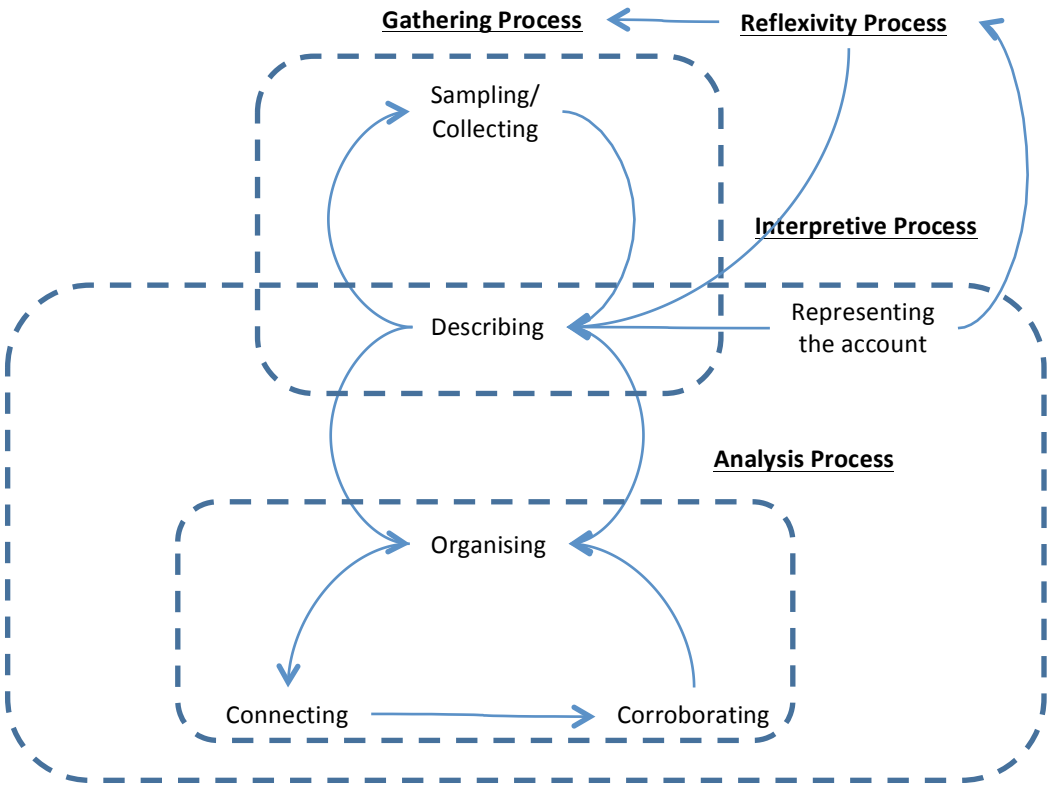

Figure 15: Qualitative Research Process (Denzin & Lincoln, 2005: 622)

Data has been gathered from extant literature; documentary evidence from the case organisation; and semi-structured interviews from respondents that met the sample selection criteria. Using a range of data collection methods served to triangulate, corroborate and validate responses (Yin, 2003) providing stronger substantiation of constructs (Eisenhardt, 1989).

The research commenced with a review of literature on the topic of requirements traceability and more specifically, pre-requirements specification traceability. The literature review expanded slightly beyond this into the context of requirements management. The literature review provided a thorough background into the theory, current practice, benefits, challenges and recommendations to improve practice as outlined in the body of research on the topic. The literature introduced the basis for the research study, which is to

fill the gap in case study insights into pre-RST and determine whether the level of awareness and value-perception has impacted the prevalence and extent of this practice in industry.

An investigation into organisational process assets such as frameworks, tools and techniques, standards or regulatory requirements relevant to requirements traceability was undertaken. This included a review of related documentation from the project management, business analysis and change management competencies. Documentary evidence from business units sampled was reviewed to determine whether traceability practices were evident from source documentation. Information held in public and private archives of both a formal and informal nature was sourced. This included published and unpublished documents, company reports, email correspondence, meeting or workshop minutes and notes, work registers, and specifications and design documents. Project documentation, specifically the business requirements specification, business case document, functional requirements specification and formal and informal workshop notes were investigated to corroborate and complement data obtained from interviews.

Research interviews have been conducted with a diverse range of stakeholders that were intimately involved in the production of requirements. The selected sample represents a cross-section of requirements-related roles from different business units serviced by the IS organisation. A semi-structured, face-to-face, individual interview format of approximately 45-90 minutes in duration each was selected, putting participants at ease whilst avoiding influences between interviewees. All interviews were conducted face-to-face other than two that were conducted through telephone and video conferencing. The researcher exercised flexibility in the interview so as to provide respondents with the freedom to share related information, observations, examples, concerns or challenges as these unfolded in the line of inquiry whilst returning focus to the topic (Schultze, 2000).

A letter inviting participation confirmed the confidentiality and anonymity to accompany participation (Refer Appendix 3). This contributed to a setting where participants felt comfortable to share their experiences and opinions. The letter introduced the field of research, the reason for the interview and the interview procedures such as audio-recording of interviews, confidentiality and anonymity. The aim was to provide participants with an opportunity to reflect on their experiences prior to the interview. At the start of each

interview these issues were again highlighted to ensure that the participants were fully aware of what was required. At the point of asking about awareness levels of the terms "pre-RST" and "RT", the researcher provided respondents with a diagram (Fig 19, p73 to ensure uniformity in the interview process. Interviews were focused around four categories of questions, namely (i) demographics; (ii) awareness of the terminology and concepts; (iii) current practice; and (iv) perceptions. Examples were requested during the interview as a means of confirming or clarifying responses. Contextual information was also sought to better understand respondents' input.

A sample interview transcript and supporting information is available in the Appendix. Interviews were manually transcribed into summary notes per interview whilst tabulating data to identify commonalities and differences using the research and interview questions as a qualitative description model. The qualitative description model was used to classify written interview and field notes manually. Original audio recordings were reviewed multiple times, listening carefully for themes, intonation, recalling gestures and selecting pertinent remarks.

To corroborate actual facts of the case, Yin (2003) recommends the research report be reviewed by informed persons who were subjects of the case study. If disagreement arises, further evidence should be sought as participants could have forgotten materials during initial data collection (Yin, 2003). This review strategy aims to enhance accuracy and construct validity (Yin, 2003). Alternatively, Yin (2003: 159) suggests that if no objective truth exists, this may reflect different renditions or perspectives of the same event, which can be represented in the case study report. The report has been subjected to review from selected interviewees within the limitations of time.

As summarised in Figure 16 below, data collection methods employed to establish current experiences and perceptions of pre-traceability practices within the organisation therefore included three core methods namely (1) a literature review; (2) documentation reviews; and (3) field interviews. It is acceptable for case study research to encompass other methods, namely surveys or examining archival data (Gable, 1994; Yin, 2003).

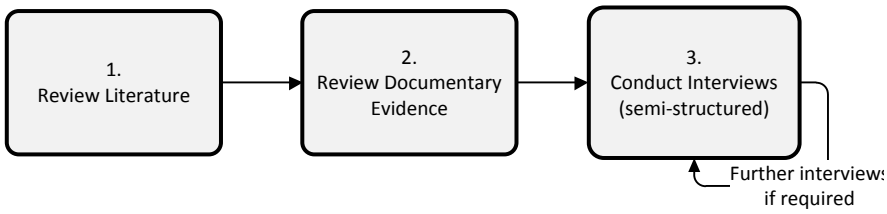

Figure 16: Research Method (Author, 2013)

The unit of analysis was a single organisation, with embedded sub-units comprising multiple projects undertaken within different business units in the organisation and experiences drawn from selected practitioners that were intimately involved in the requirements development process in these business areas. Two levels of analysis applied, namely the organisation and business unit levels.

Data Analysis

Punch (2005: 194) reminds us that "there is no single right way to do qualitative data analysis". However, meeting certain criteria lends credibility to a research study. Punch (2005: 195) favours a disciplined, systematic, transparent and describable data analysis method to inspire confidence in the research study and conclusions. Furthermore, data analysis procedures need to be adequate and appropriate for the research questions (Punch, 2005: 251). An audit trail was maintained between the various sources of input and the findings to ensure "adequate" analysis and a level of transparency that demonstrates how data progressed to findings. Procedural consistency was also maintained with the research questions to ensure "appropriate" analysis (Punch, 2005). This has been achieved through the use of an interview guide to ensure a consistent base of questions was tabled, yet allowing for the flexibility of a semi-structured interview.

Data collection and analysis overlapped, using field notes, to expedite analyses and reveal helpful adjustments to data collection as recommended by Glaser & Strauss (1967) and Eisenhardt (1989).

Interviews were manually transcribed and reviewed for recurring themes, commonalities, points of difference, gaps or omissions and noteworthy quotes across responses. Although time consuming, this allowed for an in-depth analysis of responses and validation of the

researchers interpretation of results. While reviewing, transcribing, describing and interpreting the source data, themes emerged from organising and connecting the different aspects of the overall research input. The findings and themes have been validated through corroborating input against related evidence and verification from the contributors.

Data analysis was done using qualitative forms such as analytical induction (Mouton, 2001). “The inductive researcher derives understanding based on the discussion” the “deductive researcher derives understanding based on testing or confirming a preconceived hypothesis or theory” (Krueger 1989).

Punch (2005: 286, citing Miles and Huberman (1994)) provides six “fairly classic” analytical moves for generating meaning in qualitative analysis and for testing or confirming findings that this research will observe. These include (i) affixing codes to field notes drawn from interviews; (ii) noting reflections or remarks in margins; (iii) sorting and sifting through materials to identify similar phrases, relationships between variables, patterns, themes, distinct differences between subgroups, and common sequences; (iv) isolating patterns and processes, commonalities and differences for further field exploration in a subsequent wave of data collection; (v) gradually elaborating a small set of generalisations that cover the consistencies discerned in the database; and (vi) confronting generalisations with a formalised body of knowledge in the form of constructs or theories.

Further advice from Miles & Huberman (1994) was heeded to test or confirm findings and ensure conceptual coherence. This included weighting evidence and deciding which kinds of data were most trustworthy; triangulating across data sources and methods; checking for researcher effects on the case and vice versa; and seeking feedback from informants.

Ultimately, a method of analysis that cannot be scrutinised will not generate any confidence in the findings presented (Punch, 2005).

Research Limitations

The research sample is limited to requirements practitioners at a single case organisation within the retail sector in the Western Cape. Although not insurmountable, limitations of case study research have been cited to include a lack of controllability, deductibility,

repeatability, generalisability (Gable, 1994) and the risk of improper interpretation (Gable, 1994).

The lack of generalisability is highlighted most in literature on research design, and is seen as a limitation inherent in the nature of case study research. “All management is considered contextual” which limits the generalisability of our knowledge on management practices, including practices such as requirements traceability (Morris & Pinto, 2007: 197). As the case study method does not use a large research sample the results cannot be generalised on statistical strength, instead results are generalisable based on empirical description to theory (Lee & Baskerville, 2003). The findings will therefore be specific to the case organisation. However, the case investigation could be replicated for other organisations.

Respondents, due to their intimate involvement in the projects under investigation, may attempt to conceal perceived inadequacies or treat the interviewer with suspicion (Hamel, Dufour & Fortin, 1993; Riessman, 1994; Stake, 1995; Yin, 2003). All interviews were recorded and transcribed with the interviewer guaranteeing confidentiality, anonymity and positioning the research as an opportunity to uncover broader opportunities for international research and practice. Yin (2003: 86) warns that case study interviews could suffer from reflexivity, a situation where the interviewee responds in line with what they believe the interviewer wants to hear.

The timing of the research coincided with a restructure and retrenchment of middle to senior management in the head office. The climate was therefore one of much turmoil and uncertainty for many. This may impact on the ability to secure interviews, or to access stakeholders who may no longer be with the organisation, or for interview subjects to feel comfortable with providing open responses.

Time limitations for the actual interviews could pose a risk as it may not be possible to explore in sufficient detail with participants in the allocated timeslots. Data collection and analysis could also be time-consuming which poses a further limitation, and the potential that not all participants may be traceable as they may have left the organisation (Mouton, 2001).

The potential for error exists in that the researcher is an employee within the organisation which may create opportunity for interviewer bias. The researcher's relationship to the case organisation is discussed in the section below.

Researcher's relationship to the case

The potential for error exists in that the researcher is an employee within the organisation which may create opportunity for interviewer bias. This is mitigated by the fact that the researcher was on extended maternity leave during the time the research was undertaken as the distance provides the opportunity for objective reflection. Furthermore, the researcher was neither influencing nor involved with projects on a daily basis during the research period. The researcher's status as employee does, however, provide an advantage in having an insider perspective to the phenomenon and case location as well as access to key resources and management.

The researcher is a practitioner in the field of requirements management and business information systems projects and is currently an employee at the case study organisation. This provides the researcher with an advantage in having first-hand experience both in the subject area as well as in the organisation. This "unique knowledge and experience" (Schultze, 2000: 8) and first hand involvement in the field being studied bolsters the ethnographic study. Interview input is therefore complemented by researcher insights into the organisation context and an established set of relationships with participants which encourages honest, open feedback. Being immersed in the phenomenon itself is advantageous for interpreting and contextualising findings. This is consistent with the epistemology of ethnography which requires that the researcher approach the research study as an outsider but with substantial insider knowledge.

Yin (2003) advises that the researcher should preferably know the subject and the interviewee for single case study situations. The researcher's relationship to the case organisation could also mitigate interpretation errors as the researcher's status as employee affords a broader contextual background and insights into responses provided which may otherwise be overlooked. Any metaphors, terminology or analogies used in the organisation or industry can therefore be understood within context without the risk of misinterpretation

(Clandinin & Connelly, 2000). Furthermore, the researcher has easy access to respondents for post-interview clarification and due to established and trusted relationships, is able to draw out information with relative ease and rely on respondents' honest input. Denzin & Lincoln (2005: 696); Fontana & Frey (2005) warn that the spoken or written word always has a residue of ambiguity regardless of how carefully the questions have been worded or the answers have been coded or reported.

Ethical considerations

When conducting research with human subjects, certain ethical considerations are paramount. The following measures were taken from an ethical perspective.

Punch (2005: 277) recommends that privacy, confidentiality and anonymity be considered. All data collected including audio files, transcripts thereof, and company documentation were not be disseminated and were treated with utmost privacy and confidentiality in mind. Files were password protected and securely stored. Neither the identity of the company nor the identities of the participants interviewed have been disclosed. Masking has been used in the research report and in the interview transcripts as a means of protecting participants' identities. The research report itself will be treated as private and confidential as requested by the participating organisation as a further means of protecting the organisation's identity.

A further ethical measure was to ensure that informed consent was obtained from the participating organisation. Interview candidates received an interview participation letter and consent form in advance (Refer Appendix) which outlined what the research entailed and their role in it, interview procedures such as audio-recording of interviews, confidentiality and anonymity. Candidates willingly consented to participate in the research and were comfortable discussing the subject. The researcher furthermore guarantees that no manipulation of interviewee testimony has occurred.

Significance of the Research

The intended contribution of this study is to fill the current gap in case study insights into pre-requirements specification traceability practices and perceptions in organisations,

especially “untypical contexts” such as industries where traceability has not been mandated (Gotel *et al.*, 2012c). An explicit call for current case study insights was made by the research community (CoEst, 2014) to researchers recently as it was found to be difficult to make claims about current coverage of the practice or outstanding problems in the absence of such insights (Gotel *et al.*, 2012c). The study aims to develop an understanding and explanation of a complex situation offering real practical benefit to practitioners in the longer term (Eisenhardt, 1989). Case studies have the potential to bring about new meaning, to unearth previously unknown variables or relationships leading to rethinking the phenomenon under scrutiny, or to confirm what is known (Merriam, 2009). Both research and practice could benefit from such insights and gear further investment into those practices deemed appropriate. No research into pre-requirements traceability in the South African context exists at present. This paper contributes insights into a specific sector, namely the retail sector, which will not be representative of all South African cases but will offer a window into the prevalence, perceptions and problems encountered. The study serves as an opportunity to close the gap between research and practice by investigating practical concerns related to requirements management and the potential pre-RST offers.

The findings of this research, although not generalisable, include new insights or confirmation of existing knowledge of practice. Furthermore, the research highlights opportunities for improvement; good practices to replicate and entrench; inefficiencies to avoid on future projects; and considerations to build into the organisation frameworks currently in development. Moreover, this research contributes to the overall empirical research base on requirements traceability to assist in the advancement of underlying theory.

Furthermore, whilst the case organisation currently does not routinely perform post implementation reviews, the author came across various anecdotal reports of requirements not being clearly understood and stakeholder expectations ultimately not being met that warranted an investigation into the selected research topic in the case organisation.

Conclusion

The aim of this chapter was to describe and justify the methodological framework selected for this research. As outlined in the literature review and subsequently tabled in the research question, case study insights to understand current practice with regards to requirements traceability remains lacking. To fill this gap, it is germane for the researcher to understand practitioner experiences and perceptions of pre-RST practices along with the broader organisational context within which requirements development is undertaken. A qualitative study in the interpretivist tradition has therefore been selected as suitable to achieving the goal of such exploratory research as per recommendations from methodologist sources quoted in this chapter. A single case study strategy was selected with an interview-based method for collecting the type of rich data sought. Documentary evidence served to supplement the interview data. Potential limitations of the research method applied has been presented and mitigation tactics where feasible.

CHAPTER 4: CASE ANALYSIS

4.1 Introduction

This chapter describes the results of the interviews held with requirements practitioners and participants. The interviews probed the level of awareness, practice, value-perception and concerns regarding the practice of pre-RST across IS-intensive projects within selected business units within a retail organisation. It commences with an overview of the participating business units represented in the research and demographics of the interview participants. The findings are then presented in accordance with the four categories of inquiry pursued, namely awareness of the concept or practice; current practice in the organisation; value-perception; and challenges to investing in pre-RST.

4.2 Business units represented

The IS division serves as an in-house consulting and service delivery organisation to the broader business. Each business unit is represented in IS through a business-facing business delivery manager and a team of business analysts who are responsible for defining and interpreting business needs into technical solutions, a process that spans from project initiation to implementation. Since the focus of this research is on requirements traceability within the scope of IS-intensive projects, data was primarily sourced from those most intimately involved in the requirements development process. Participants selected therefore either fulfilled the role of requirements participant or contributor, namely project sponsors or champions, or requirements practitioner, namely the business analyst or business delivery manager. For insight into organisation-wide practices, IS management and the central competency office responsible for frameworks and governance were also consulted.

Five departments, or business units (BUs), were represented in the research. BUs represented included the recently established **IS Solutions Delivery and Governance Department**, responsible for frameworks and governance across project management, business analysis, change management, IT architecture and quality assurance disciplines. Another newly formed area, approximately 3 years old, the central **Supply Chain Division**,

participated in the research. This specialist, centralised division has been created to significantly expand the supply chain capacity, replacing a decentralised, independently functioning set of regional warehouses. Despite being a relatively new department, it has been described as the most mature area with respect to structure, discipline and process-maturity. The **Merchandising Division**, similarly, has recently been centralised with significant and complex transformation programmes in progress to improve the organisation's merchandising capability. This BU was under significant transformation, leadership change and uncertainty at the time. The **Store Operations Division** was also represented. It operates as a decentralised, regional structure, with roles duplicated yet varying across regions and accountabilities regarding business processes unclear. The final BU that was represented was the **Marketing Division**, a small and centralised BU where usually very few stakeholders contributed to, and approved, requirements.

4.3 Demographic information - Respondents profile

Participants provided a brief background as to their current and historical roles and experience at the case organisation and, more specifically, their role in the development of project requirements. Where interview time was limited, background information was obtained via post-interview inquiry via email, telephone or electronic chat. All respondents had a minimum of 3 years' experience at the organisation and overall working experience in an IS environment ranged from 10 to 30 years. Participants were all experienced in requirements development within IS related projects, having worked on projects that ranged from small initiatives with a contained stakeholder base to larger, complex and far-reaching projects with stakeholder and sponsor involvement varying from active to absent.

Respondents were identified using pre-defined criteria aimed at extracting experiences in the practice of requirements development across different business units. This provided the opportunity to gain insight into similarities and differences across BUs whilst being mindful that eleven interviews may not qualify the research as generalisable.

Projects were predominantly staffed by consultants and contractors, estimated at 70% of the total staff complement at the time, compared to a much smaller base of permanent

employees. Including a minimum of 3 years' service at the organisation in the selection criteria therefore whittled down the potential interview candidates significantly.

Role	Total Incumbents (filled roles) A	Potential Interview Candidates (>3yrs service) B	Interviewed (actuals) C	% of Potential Candidates interviewed (C/B)
IS Business Delivery Manager	3	3	3	100%
IS Business Analyst	20	4	3	75%
IS Solutions Delivery Competencies	7	5	2	40%
IS Management	6	3	1	33%
Business Manager/Leader	10 Business Units	10 Business Units	2 BU's represented	20% at BU level

Table 1: Interview representation by role (Compiled from Research Interviews, 2013)

Thirteen respondents were initially identified of which eleven were successfully interviewed. The table above shows that despite interviews being limited to eleven, these represented a substantial percentage of candidates that met the selection criteria. The candidates selected were predominantly project practitioners within IS that served as the interface between the IS division and various business units with respect to defining and delivering against business requirements. Four of the five business partnering departments within the IS division were represented in the research. In addition, the BA and PM frameworks and governance managers; a member of the IS management team; and two business managers were interviewed. Table 2 below summarises the current and historical experience profile (*i.e.* over the duration of their careers) of respondents by requirements related role.

Requirements development experience	Current Role (No. of respondents)	Historical Representation
Requirements provider	4	4
Requirements analyst/manager	6	9
Frameworks & Governance	3	4
	13	**16**

Table 2: Summary of respondents by requirements role (Compiled from Research Interviews, 2013)

Various requirements related roles, namely requirements provider, requirements analyst or manager, and requirements frameworks and governance were therefore represented.

4.4 Discussion of the findings

The line of inquiry pursued during the interviews was broadly divided into four parts, namely:

1. **Awareness** of the research subject, concepts, and terminology
2. **Current practice** employed at the organisation, both formal and informal
3. **Value perceptions** and appetite for implementing pre-RST practices
4. **Perceptions** as to **challenges** to be addressed if implementing pre-RST practices

The findings from responses to each of these areas of investigation are detailed below.

4.4.1 Awareness of the research subject, concepts and terminology

Respondents were unanimous in their feedback that they had never encountered the term pre-RST.

> Respondent 9: "It's the first time I've heard that"
> Respondent 2: "In terms of the second term (pre-requirements specification traceability), I've never heard that used in our context. I don't see it as something that is formally implemented or spoken about generally"
> Respondent 4: "No, I can't say that I've heard those terms"

Neither RT nor pre-RST was mandated by the case organisation as confirmed by Respondents 2, 5, 10. Consequently, it may be expected that exposure to the terms was limited amongst the respondents. Whilst exposure to pre-RST was non-existent as reported above, some exposure to the term RT was reported. Nearly half of the respondents (5 of 11) reported that they were not familiar with the term RT, with the remainder reporting varying sources and levels of exposure (See Figure 17). Three respondents reported a detailed understanding of, or experience applying, the practice in a work context (See Figure 18). These three respondents all have experience in a business analysis role and a formal business analysis qualification. The remaining eight respondents had little or no exposure to the term and represented an equal proportion of business management, IS management, business partner and business analyst roles.

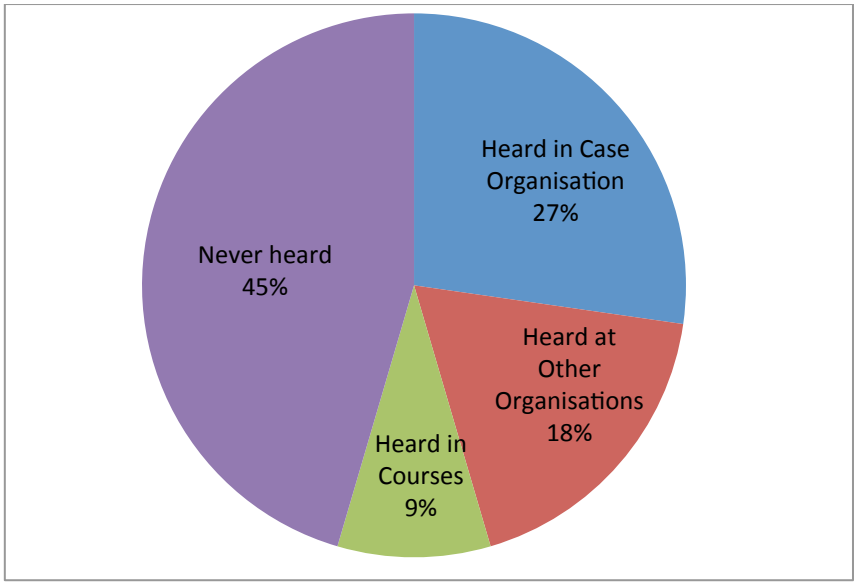

Figure 17: Awareness of the term RT (Compiled from Research Interviews, 2013)

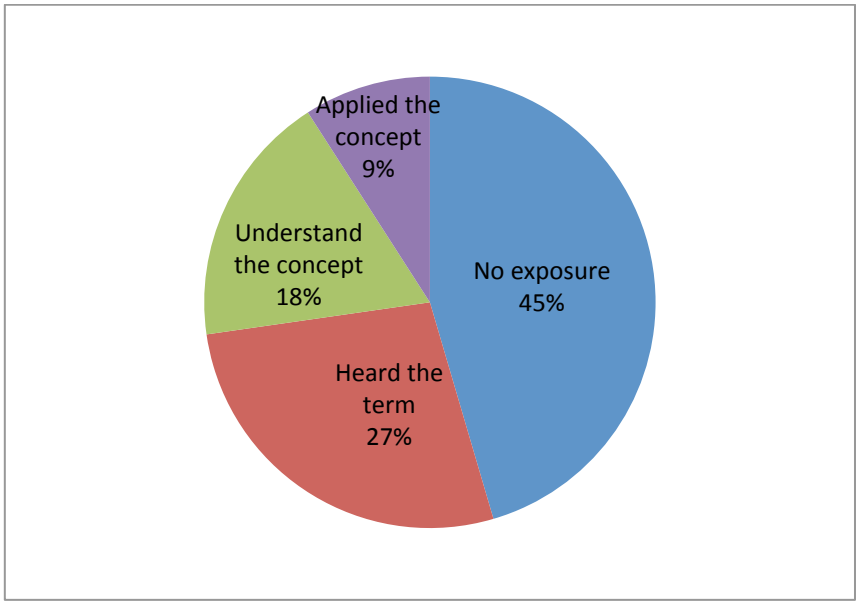

Figure 18: Level of exposure to the term RT (Compiled from Research Interviews, 2013)

Respondents were not aware of any consistent, deliberate, pre-defined standard in the organisation, confirmed by two respondents in frameworks and governance roles who reported that no mandated practice existed although this was under consideration for inclusion within the developing BA framework (Respondent 5). Respondent 5 shared that traceability of requirements was logged as a key criteria in a recently compiled request for proposal (RFP) document prepared for an enterprise architecture tool.

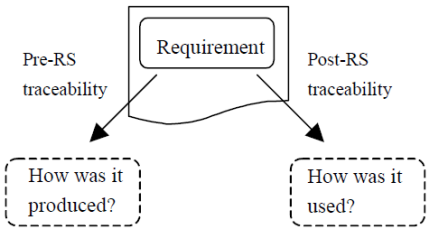

Figure 19: Pre-RS and Post-RS traceability (Pinheiro, 2004: 94)

Upon explaining the concept with the aid of a simple diagram (See Figure 19 above) to establish whether a similar concept or term was in use, the common response was that a general awareness existed with respect to the concept, but that practices to support this was limited and no conscious thought of effort had been expended thinking about pre-RST.

> Respondent 2: "I think there's awareness of requirements traceability, but I'm not aware of a formal process where we do it currently other than the stock standard 'spec' that gets signed off and gets delivered against. I'm not aware of a process where we go afterwards and we try and make sure have we checked off all the requirements that were originally put on the table."

While describing their practice as inadequate and not robust enough, Respondent 7 confirmed their realisation of its relevance:

> "Although we may not use that terminology, we certainly work to the principles of making sure we document and have understood the why, the when and the how, and that its longevity is longer than the person doing the job."

In response to the concept, Respondent 1 ushered a resounding "*that makes sense*" as something that can enhance project processes yet is "*not formally considered in the real world*".

Most respondents reported not considering the concept in an explicit manner in their projects with Respondent 7 commenting on the potential reason for this, describing traceability as "*a comfort blanket*" often only needed "*after the fact*", well after project completion, when changes to solutions are needed or decisions are revisited.

> "If all goes well then who cares to go back to the first idea, everyone's moved on already. But when things go wrong then people want to go back" (Respondent 7)
>
> "It makes sense but you don't think about gathering requirements like that" (Respondent 1)

Discussion

The experience at the case organisation regarding the limited awareness and use of the terms requirements traceability and pre-RST is consistent with reports in the literature. Gotel *et al.* (2012c) reported that the term 'traceability' itself was not widely recognised or used in practice despite a level of formal or informal efforts in place to achieve traceability on projects. The case organisation, through the absolute lack of awareness of pre-RST, reinforces the notion amongst researchers that pre-RST is the more neglected aspect of traceability.

A starting point for introducing the practice is to start with raising awareness. A carefully considered introduction of these terms into the organisation's spoken language is a logical starting point. The terms should be introduced in a manner that fosters standardisation and shows its practical use so as to start off on the right foot. The lack of standardisation in terminology and definitions has been reported as a significant obstacle to achieving successful traceability implementations (Stepanian, 2004; Bashir & Qadir, 2006). Inconsistency in definitions is reported amongst researchers as well as practitioners (Gotel *et al.*, 2012c) and by implication, could result in inconsistent implementation (Ramesh, 1995). A consistent definition amongst project practitioners is therefore advised when introducing the practice (Bashir & Qadir, 2006).

Despite reports of informal practices in place, without awareness amongst practitioners, traceability will remain an after-thought only considered when such a "*comfort blanket*" (Respondent 7) is needed, which is well after project completion. As the value is only realised after the project has closed, traceability remains neglected when starting projects and work practices therefore continue to reflect inadequate preparation and consideration. Explicit consideration for traceability at the start of a project is required so as to design an appropriate means to satisfy traceability needs upfront. The initial stumbling block to overcome is therefore as basic as awareness amongst practitioners. It also seems apparent that lessons learnt from projects are not carried forward into improved project practices in the case organisation. Considering project lessons and the traceability needs raised at the end of a project, organisations may be able to identify traceability information it intends to

use and therefore capture. (Ramesh, 1995) lists identifying potential usage and what to capture as the first step to implementation.

The roles expected to have the most exposure to the term is in the business analysis discipline, namely the business analyst and business delivery manager. Responsibility for requirements management, which encompasses management of the traceability of requirements, is commonly assigned to roles within this discipline as outline by the International Institute of Business Analysis (2009). However, 4 of the 7 business analysis roles interviewed had limited or no exposure to the term. These respondents did not have formal BA qualifications, but had in excess of 8 years' experience in the role. Although not generalisable, this could indicate that the expectation that BA roles should be familiar with the concept may not hold. Respondent 5 expressed disappointment at not hearing traceability sufficiently in the BA community.

> Respondent 5: "I would expect to hear this more in the BA community".

BA's with formal BA qualifications revealed a detailed understanding of traceability yet only one had applied it in practice. This may highlight an opportunity for training and academic institutions to reconsider how traceability is designed into courses. As pointed out by Aoyama *et al.* (2010), overall training and practice with respect to requirements engineering was lacking in industry, especially considering that neither requirements analyst nor requirements engineer were established professions. A requirements body of knowledge should therefore provide clear guidance to practitioners related to pre-RST (Aoyama *et al.*, 2010).

4.4.2 Current practice

The limited exposure to the terms RT and pre-RST as reported above did not equate to a lack of traceability in practice, albeit informal, or to an inability to trace back to contributors and their contributions towards requirements. All respondents reported that they were able to trace back to sources although this was, however, achieved with varying degrees of difficulty with only one able to do this with relative ease. Trace information was described as being:

> "dispersed, and based on what various individuals may have documented" and "will not be easy to find" (Respondent 3).

Interview responses yielded mostly reluctant, hesitant responses (Respondents 1, 2, 3, 10):

> "Yes, we probably could trace to sources or to a group of people, but with difficulty" (Respondent 1).
> "In certain areas, yes. Others, no" (Respondent 2).
> "No, we wouldn't be able to trace it back to the person, but we would be able to trace it back to a particular (blueprinting) workshop and list who was represented in that workshop, not the person, nor the reason they raised it" (Respondent 3).

Respondent 2 reported that no formal attempts were made at tracing requirements at the organisation in his experience.

> "Have I ever seen an example where we've actually traced requirements formally, the answer would be no", Respondent 2.

Those in the frameworks and governance areas confirmed that no mandated practice was in place (Respondent 5, 10), but that this was a fundamental aspect of the BA framework under development (Respondent 5).

Respondents 2 and 3 concurred that finding sources of requirements in decentralised BUs, where ownership and accountabilities were unclear, often proved difficult. Centralised BUs had positions with clear accountabilities for specific process areas and no or minimal overlap. Locating the sources of requirements in these instances was therefore much simpler as the substance of the requirement indicated its origin.

Traceability practices

When comparing the selection of pre-RST techniques discussed in the literature review to actual practice evident from the case organisation, it is clear that no formal practice, strategy or models exist to cater for pre-RST at the case organisation. The table below provides a brief comparison against commonly cited pre-RST techniques discussed in the literature review.

Tool/technique	Are any features evident at the case organisation
Requirements Specification	This is the most commonly used requirements artefact. Trace information is limited to author and approver at a document level. In exceptional cases, issues, discussion, decisions and their sources are recorded but this is done based on the discretion of the BA (Respondent

	9, 11).
Requirements Traceability Matrix	This is used by one respondent to record the source of a requirement for ease of reference (Respondent 11). No further detail regarding rationale, decisions, context or additional contributors recorded.
V-Model	Translation across requirements artefacts was not evident especially since business case documents were not commonplace. The value proposition was therefore not necessarily linked down through to actionable implementation requirements (Respondent 10). One BU, the more mature Supply Chain division, was able to trace requirements back to business strategy through a more structured means of record-keeping and storage in a shared repository (Respondent 7).
Contribution structures	Role-based traceability analysis is not available given the sparse information documented at the organisation. The Contribution Structures model expects the web of relationships among contributors, namely documenters, authors, sponsor and artefacts resulting from their contributions, to be recorded which is not evident at the case organisation. Dependencies and decomposition of requirements is also not available at the case organisation. Contribution Structures require a metamodel for its use and maintenance which is also not in place at the case organisation.
PRO-ART	None of the features of the PRO-ART model is evident at the case organisation. No method exists for transitioning requirements from informal to formal specifications. Neither is the completeness nor coverage of a requirement recorded. The level of agreement is limited to whether sign-off of the requirements document has been obtained or not. PRO-ART requires more detail than this level of agreement. No automation or trace repository is in place.
Ramesh & Edwards	The trace information and relationships recommended by the Ramesh & Edwards (1995) model includes assumptions, rationale, alternatives, decisions, derived requirements, issues, critical success factors, and standards/policies/methods. Some of this information is recorded in emails or informal notes, and in certain exceptional cases in the requirements specification, but not in a consolidated and inter-related model for common reference.
iTrace	iTrace recommends a snapshot is kept for every iteration of requirements elicitation, to accompany the requirements specification by version. Such a snapshot is not evident at the case organisation. Workshop notes are, however, kept, and informal personal notes are kept by BA's for their own records (Respondent 4, 9, 11). If a consistent means of capturing snapshots is setup as a standard, existing informal notes could be captured and attached to the requirements specification with minimal overhead. The foundation for this, being informal workshop notes, is therefore in place.
TRACS	No automation is in place.
Contribution Structures extended with RTM	Neither contribution structures (as noted earlier in this table), nor an extension thereof through the use of an RTM is evident from the case organisation.

Table 3: Comparison of pre-RST practices to case organisation (Author, 2013)

As evident from the table above, no formal pre-RST strategy or model was in place at the case organisation. Traceability practices were employed based on the individual's preference with no mandated standard in place. As highlighted in the earlier section on awareness, no upfront consideration is made for pre-RST when starting a project as the need for traceability is only realised at the end of a project.

Most respondents did not have readily accessible supporting information to trace requirements to their sources. Where available, requirements related information had not been catalogued or structured for the purpose of traceability and therefore required detailed searching, a reliance on memory as to when or where workshop or related notes may have been archived and multiple attempts at appropriate search keywords or phrases to filter information.

The techniques or methods by which respondents most commonly traced requirements back to their source has been summarised in Figure 20 below, and followed by a description of the practice. The graph depicts the frequency with which each method was raised by respondents in the interviews.

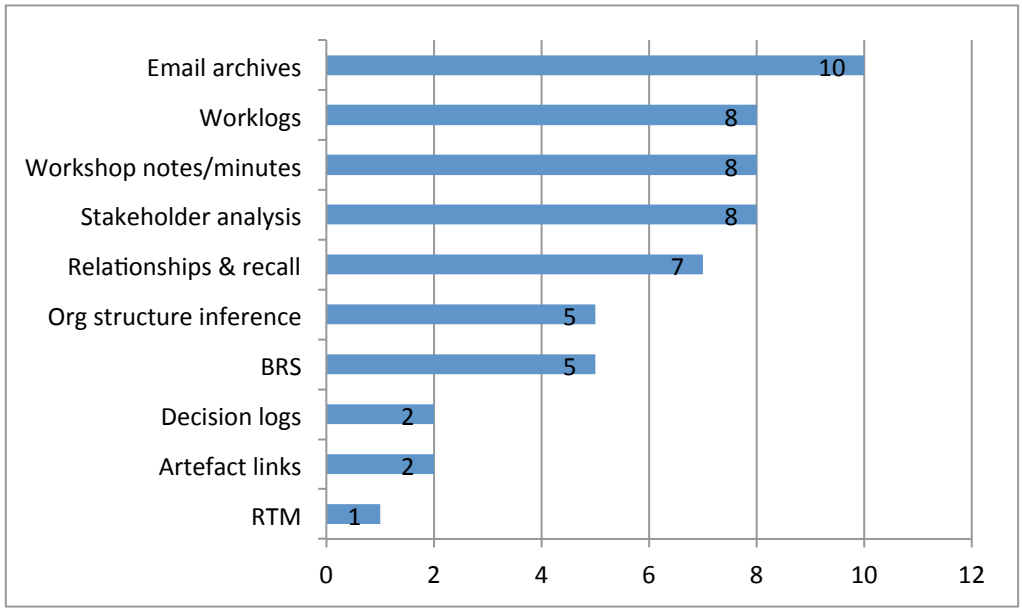

Figure 20: Current traceability methods (Compiled from Research Interviews, 2013)

Email archives: All respondents kept email archives which served as the most popular documentary source of reference for traceability. Email archives were filed according to project name or stream which served as the most significant categorisation of content.

Worklogs: Further documentary sources kept by business managers and business partners included work logs with brief requirements statements and business owners.

Workshop notes/minutes: All respondents in the BA discipline reported keeping workshop notes either in emails, as formally documented meeting minutes and circulated these to relevant stakeholders, or in rough notes for their own reference. However, requirements sourced in a workshop were not traceable to the exact individual as workshop notes generally did not include this level of detail unless a judgement call was made by the business analyst to do so (Respondents 3, 6, 9, 11). Investigations and discussions with individuals were, however, more common for sourcing requirements than requirements workshops (Respondents 4, 9, 11). Informal notes and email were kept as evidence of such investigations (Respondents 4, 11).

> "The only evidence is an attendance register for blueprinting workshops. We wouldn't keep detailed minutes. We keep notes against a high level process structure, for example against inbound receiving, we'll have an attendance register of who attended that workshop" (Respondent 3)

Stakeholder analysis: Those in BA related roles all performed initial stakeholder analysis to determine who the sources of requirements and participants in requirements or process workshops should be, although this exercise was felt to be too informal and inconsistent to be considered reliable. Evidence kept related to this stakeholder analysis exercise was limited to recording names of workshop participants and attendance in workshop minutes. Respondent 5 commented that, if done well, stakeholder analysis could reliably determine the sources of requirements upfront. Respondent 8 reported stakeholder identification as a key activity done upfront where ownership and accountability was determined through agreement with directors and senior managers:

> "My preferred approach is to assign an owner and validate that ownership within realms of that business, by directors and senior leaders. The owner needs to get consensus by speaking to various role-players in that business area and represent this back to the project. For example, receiving process owners get input and consensus from receiving clerks." (Respondent 8).

These business champions therefore represented business needs and were held accountable for decisions by Respondent 8 who, as a senior business manager, was able to hold individuals to account and reported doing this often to resolve conflict. Tracing sources of requirements was considered simple for this respondent due to his involvement in selecting the participants, intimate knowledge of the organisation structure and well-established, longstanding business relationships. Respondent 8 emphasized being firm about ownership, accountability and thoroughly interrogating contributions at the outset thereby eliminating a need for retrospectively determining sources, "*get the ownership at the start, in the main*". However, this respondent reported difficulties with ownership when undertaking business innovation and "*out of the box type stuff*", which had to be "*approached in a different way*" with "*requirements coming from a slightly different direction*", not being able to use the same representatives as "*you can't leave all the innovation to the operational guys, their job is to buy and sell products*". Instead,

> "go to someone you know and trust in the (business) community that knows the company needs to change" to avoid innovation being rejected too quickly (Respondent 8).

Reflecting on stakeholder analysis, ownership and accountability for requirements, Respondent 8 commented that:

> "you need to know business people to get this right".

Relationships and recall: Traceability was found to be largely facilitated either through longstanding relationships or memory. As indicated by Respondent 2, "*we know the people*", "*have good working relationships*", "*the team is stable*" and therefore will be able to identify sources but this will be through "*manually locating sources through people and history*". Respondents were, in these circumstances, able to pinpoint requirements to the most likely individual or to a group upon examining the requirement and consulting their business networks. The context and rationale behind the requirement, however, had to be recalled from memory, inferred from the type of requirement, unearthed from email archives and notes taken during requirements gathering, or requested from original contributors once located.

Often, significant periods elapsed between the crafting of the requirement and the need to trace its source. This was due to requirements often being postponed, and then resurrected

multiple times over a protracted period (Respondent 11). Reliance on memory thus proved unreliable and with project teams changing and the majority of the BA community being new to the organisation (Respondents 2, 5, 8). Whilst strong business relationships were useful, consulting business networks to manually recreate the context and rationale for requirements was inefficient, time-consuming and unreliable.

Organisation structure inference: Most respondents commented that traceability was significantly easier in centralised organisation structures where role accountabilities were clear. In these circumstances, it was easy and "*obvious*" as to where requirements originated as the organisation structure and accountabilities dictated responsibilities for categories of requirements. Roles were however, not always clear in the organisation, especially in decentralised business units (Respondents 2, 3, 8, 9, 11).

Requirements documents: Requirements were formally documented in Business Requirements Specifications (BRS). However, BRS documentation was not uniformly completed despite a corporate BRS template in circulation. Naming and numbering conventions, for example, were not mandated and therefore no uniform approach was in place. BRS documents kept a record of document approvers at a document level and not an individual requirement level. These were usually business managers and business champions identified as project representatives. The rationale behind requirements was not captured, nor was the evolution of a requirement documented. Only one respondent noted key decisions and discussions related to requirements in the BRS and did so by exception for potentially controversial requirements that involved extensive debate.

Although used as the primary source of requirements, the BRS provided very little requirements traceability other than a list of approvers and a summary history of changes to versions which did not detail specific changes to requirements or associated reasons (Respondent 3, 11). Respondent 2 commented that analysts relied on the memory of requirements approvers to determine the rationale for a requirement if the need to re-examine it arose.

Decision logs: Two respondents in management positions (Respondent 1, 8) referred to a practice of recording principle decisions and decision makers, termed "*Level Zero Principle*

discussions", applied during an ERP implementation in accordance with the standard practice recommended by the ERP vendor. This was considered sufficiently robust for such a large-scale implementation and both respondents that made reference to this, recommended principle discussions be recorded as an adequate level of traceability going forward. Respondent 8 kept a cabinet of printed files of project workshop minutes from the ERP implementation, categorised by application functionality or business stream, that he referred to for decisions taken but not to determine who the source of the requirements were as the respondent was clear on accountabilities for various streams and was involved in selecting workshop participants.

Artefact links: Translation across requirements artefacts was not evident especially since business case documents were not commonplace. The value proposition was therefore not necessarily linked down through to actionable implementation requirements (Respondent 10). However, a loose and unstructured form of tracing capability existed through centralised documentation storage according to one respondent. Respondent 7 from the Supply Chain business unit, a business unit unanimously described as having the most mature project and requirements practices in the organisation, reported that all documentation was stored in a public forum, held on a shared drive, including *"strategy, principles, key performance indicators, any agreements or sign-offs"* which allowed them to *"pin it (a requirement) down at a high level"* but further detail *"will take a bit of farming"*. However, this respondent also reported that documentation was not structured in the *"right order, for the right reason"* and that not everyone knew that the documentation was available. Respondent 7 added that:

> "I don't feel we have something that is robust enough and has longevity where you can dig into archives in 15 years' time to find out why we decided to build a DC (Distribution Centre) where we wanted to. We documented it, but I don't think cohesively as a business we have something that has longevity. Everything is filed on our shared drive and now on Sharepoint, down to minutes."

Various respondents described documentation as unstructured, inconsistent and not held in a common shared repository which posed a risk to the organisation (Respondents 5, 6, 7, 9). Therefore, collating documentation for the purpose of establishing traceability across a range of requirements would prove extremely cumbersome. Furthermore, significant documentation losses were experienced during a recent organisation rationalisation, a

further risk to traceability (Respondent 5). Given these circumstances, respondents felt it would be significantly more expedient when joining a project to talk to stakeholders than to attempt to collate and trawl through unstructured records (Respondent 2, 3, 9). Artefact links were therefore found to be either weak or missing.

Requirements Traceability Matrix (RTM): One respondent reported being able to trace to requirements with relative ease due to the RTM incorporated into her work practices from an external business analysis course (Respondent 11). This RTM allowed her to catalogue requirements in a format that provided an easy lookup to the sources of requirements and inter-dependencies between requirements. The RTM cross-referenced requirements documented in the BRS which included a numbering and naming convention for easy reference. This numbering and naming convention was found to be unique to this respondent and had not been mandated. More detailed contextual information was held in archived emails but was not considered as easily accessible as the content in the RTM. This system had not been shared with the team and was seen as a personal organisation system.

Discussion

Pre-RST practices were found to be very limited, informal, unwieldy and unreliable at the case organisation. No formal pre-RST practice had been considered at the organisation with the realisation of the need for pre-RST occurring towards the end of a project when it was too late to implement a suitable model or approach. No pre-RST strategy, models or automation were in place. The case organisation therefore fits the findings in the literature that most companies either do not implement it or implement it in a haphazard manner (Yu, 1997; Ramesh, 1998; Cleland-Huang *et al.*, 2004; Cleland-Huang, 2011; Regan *et al.*, 2012). Information about requirements production, as per the literature, was found to be "lacking, unreliable, inadequately described and maintained" (Gotel & Finkelstein, 1997; Gotel *et al.*, 2012c) which meant projects experienced weak links between requirements and their sources.

Whilst all respondents had some form of evidence to refer to, these were predominantly informal notes, and did not serve as an adequate or efficient means of tracing requirements to sources over time as outlined in the comparison of actual practice to common pre-RST

methods and their features (Refer Table 4.3). Respondents reported being able to find sources if needed but this was often achieved through consulting their business networks with reliance on memory which does not offer reliability, nor efficiency.

Although informal and unstructured, interviews revealed that the majority of respondents had implemented some level of traceability either through personal email archives, workshop notes, or through more structured matrices with numbering and classification systems. These informal practices were not supported by any tools and were generally limited to the name of the requestor on worklogs, the name of the approver on requirements specifications, a list of attendees minuted in workshop notes, relevant dates, and in rare circumstances, the rationale for the requirement, pertinent discussions and decisions.

The requirements specification served as the formal source of recording requirements. This was not used uniformly or consistently in the organisation across all initiatives at the time, but practices were felt to be maturing in this regard (Respondent 1, 4, 5). As per Gotel & Finkelstein (1995's) findings, contributors listed in the requirements documents at the case organisation were limited to the author, owner or approver, a “coarse practice” involving adding more names to the document as changes were made but not attributing requirements or changes to specific sources. As warned by Gotel & Finkelstein (1995), this practice was insufficient and misleading. Furthermore, the IEEE Guide to Software Requirements Specifications only considers a software requirements specification to be traceable if the origin of **each** of its requirements is clear and if it facilitates the referencing of each requirement in future development or enhancement documentation (Bashir & Qadir, 2006). Based on this definition, the requirements specification at the case organisation cannot be considered traceable.

Respondents concurred that requirements related documentation should be, yet was not, a cascading set of artefacts from the business case through to the requirements specification and related technical specifications. This was mostly due to the absence of, or lack of access to, business case documents. Respondents in the roles of requirements providers felt that the business strategy was clear and that requirements flowed from the strategy regardless

of whether formal business case documents were always in place (Respondent 7, 8). With business case development not being an entrenched activity, requirements development teams were left to assume the justification and rationale for an initiative and were not able to link requirements in a BRS back to a business case, a business strategy or the originating contributions to an initiative.

Given the different organisation structures and levels of maturity within the organisation, it may be argued that a single approach may not be applicable across the organisation. Tailoring to the needs of the trace requirements in the specific BU may be required. Regan *et al.* (2012) recommend a flexible approach to choosing techniques as being prudent and prioritising requirements to base the selection on, ensuring a balance between cost and quality.

4.4.3 Value perception

All respondents agreed that pre-RST could improve the requirements process in their organisation and alleviate certain problems experienced on projects:

> Respondent 5: "It's important to maintain that golden thread."
> Respondent 8: "It is important. I go back to original SAP (ERP) files often to answer why, where did it come from, how did we build this."

Respondents all felt this to be an intuitively useful practice yet were measured about its implementation and practicality:

> "My immediate reaction is 'yes' as it would be useful, but in a practical and pragmatic way", Respondent 1.
>
> "No-one thinks **and** acts on knowledge management or practices such as this. We know instinctively that it's good and will benefit us in the long run but don't have time to do it and don't have time to consider how to go about it. Therefore, it's not really considered.", Respondent 2.

Respondent 5 commented that business requests for traceability had recently increased which he attributed to a shift in business ownership for their own processes.

> "There's a lot of things that we (IS) pushed into the business. They (business) must understand their business process. They need to take ownership of their business processes and they need to take ownership of their problems. It's becoming crucial that they understand exactly what they've been asking for.", Respondent 5.

"They (business) want to understand exactly how we arrived at this conclusion. They want to know where requirements and decisions came from.", Respondent 5.

This demand for traceability information from business users reflects its potential value, especially if positioned in a manner that addresses the needs of traceability users. Respondents 2, 3 added that more value may be obtained from pre-RST in decentralised divisions where roles and accountabilities were unclear and a broad stakeholder base, including third parties, had to be dealt with. Smaller, centralised teams, where requirements were predominantly provided by one or two stakeholders, would not receive sufficient value to warrant excessive investment in a pre-RST practice, as raised by Respondents 4, 6. Pre-RST would therefore provide significantly more value in decentralised structures.

Respondents raised various benefits they perceived as obtainable from pre-RST. These ranged from the ability to audit decisions to driving commitment and accountability and resolving conflict. Potential benefits as perceived by respondents have been graphically summarised in Figure 21 and expanded upon in the section below.

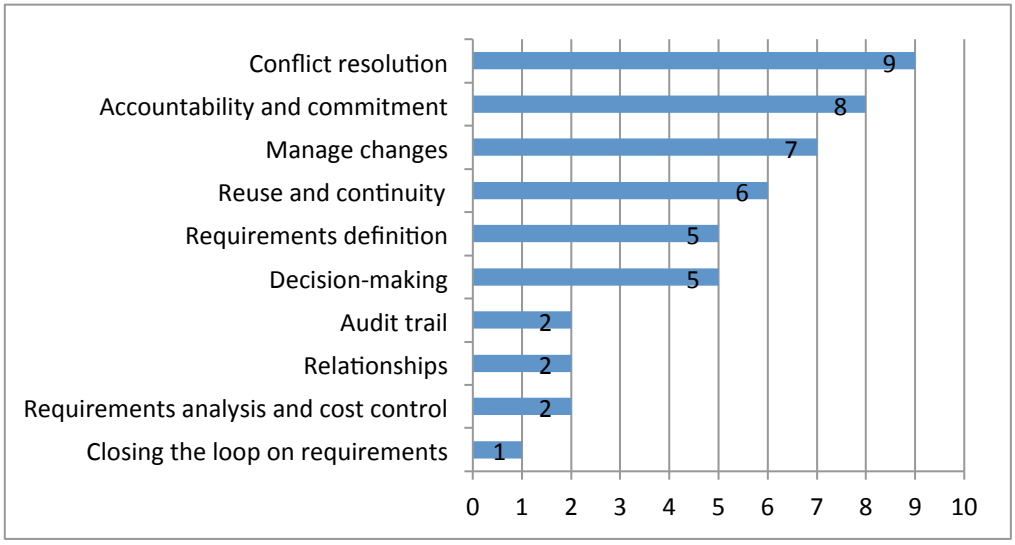

Figure 21: Perceived benefits (Compiled from Research Interviews, 2013)

Conflict Resolution: The most frequently cited benefit raised by respondents was the ability to resolve conflict amicably, objectively and quickly through referring to easily accessible and irrefutable evidence and rationale (Respondents 1, 2, 4, 5, 8, 10, 11).

"*It could cut the conversation short when conflict arises*", Respondent BK.

Accountability and commitment: Another frequently raised benefit was to drive business commitment, ownership and accountability, a critical aspect to requirements management deemed lacking in the organisation (Respondent 1, 2, 5, 9, 10, 11). Respondents felt that business sponsors and requirements providers would take more accountability and show a sustained and active interest in the project from requirements through to implementation if they knew that requirements would be linked back to them and that they may be called upon to explain the rationale (1, 2, 3, 5, 7, 9, 10, 11). Respondent 1 felt that evidence and traceability of key decisions could assist with driving accountability and avoiding costly, time-consuming and counter-productive conflict. Respondents felt that pre-RST may eliminate situations where projects continued without sustained commitment (Respondent 10), wasting time, money and effort. The historical context of ownership was raised as a situation where the IS division played an innovation role defining requirements and solutions on behalf of the business with limited input from business who were primarily focused on trading.

> "You can't leave all the innovation to the operational guys. Their focus is on buying and selling product", Respondent 8.

This context, as reported by Respondent 5, was shifting in that business participation and ownership in defining requirements was increasing. Business managers were therefore requesting evidence and background to requirements, solutions and decisions as they were playing a more active role in projects.

An example was shared that highlighted where pre-RST may have assisted with commitment and retaining the thread from idea to implementation and allowing for validation during the project lifecycle. The example involved an idea from a business leader that was implemented without detailing its evolution or business requirements. The original need and rationale became lost as the idea evolved, as constraints and implications were encountered, and the business leader's involvement dropped. The solution differed significantly from the original need; its usefulness was questioned during the pilot implementation; and it did not proceed beyond the pilot (Respondent 1).

Manage changes: Respondent 1 remarked that *"projects are often based on ideas and it's not always possible to trace to these originating ideas" w*hich results in solutions sometimes

varying significantly from the original requirement. Various respondents viewed pre-RST as a means of improving the way changes to requirements are managed and filtered through to the solution and related requirements (Respondent 9, 10, 11). Requirements often evolve whilst solutions are under consideration or even during solution development. Pre-RST would highlight dependent or linked requirements and provide a history of how requirements evolved along with stakeholders involved. This information will allow for considering impacts and consulting relevant stakeholders before accepting or effecting change requests. This could improve the fit between requirement and solution.

Reuse and continuity: Various respondents referred to a frequent need for revisiting cancelled or postponed requirements (Respondent 2, 11) in a manner that allows one to pick up the conversation from where it had been left off, thereby saving time. The assumptions and conditions at the time the requirement was originally specified may have changed, but with adequate traceability the original context and assumptions could be raised for review (Respondent 2, 9).

Respondents 1, 2 put forward that pre-RST could provide the ability to revisit sponsor ideas or stakeholder requirements previously logged for future releases so as to avoid embarking upon or continuing work not thoroughly validated or no longer relevant. This would be particularly useful as Respondent 2 observed that requirements are often delayed for consideration in future releases of software. Pre-RST was therefore considered a potential mechanism to improve planning and continuity.

In addition, an organisation wide restructure and significant changes in leadership was underway at the time of the research. This organisation restructure heightened the impact of losses in intellectual property, knowledge and continuity experienced during such restructures. Pre-RST was considered a means of mitigating the risk of people losses and changes through providing access to the rationale and history behind requirements. Various requirements and projects had either been cancelled or put on hold after the restructure due to a lack of insight into the original reasons behind the requirements, with some of this context and evolution only known by the business leader who had since left the organisation (Respondent 2, 5).

Better requirements definition: A formal "tracking mechanism" could result in business stakeholders being more circumspect when providing requirements (Respondent 2) and more active and alert during requirements elicitation, particularly in requirements workshops (Respondent 2, 3, 9, 11). The value of improved commitment and more active participation would manifest as better defined and more carefully considered requirements that business stakeholders truly commit to as necessary and valid (2, 9, 10, 11).

Decision making: Access to the rationale and evolution of requirements over time was cited as valuable by Respondent 5, enabling project decisions to be made based on information accessible beyond organisation restructures or leadership changes. A further benefit raised by Respondent 1 was the ability to quickly reference decisions taken, "level zero principles" agreed upon and insight into the context within which decisions were made, thereby informing future action.

Audit trail: Claiming "*It's paramount to have an audit trail",* Respondent 7 raised the need for an audit trail of decisions for internal audit purposes. Respondent 7 referred to RT as a "*comfort blanket*" only required in retrospect well after the project and solution had been implemented. Specific reference was made to the Audit division requesting evidence for decisions at a much later point after the project had closed (Respondents 5, 7). In this case, meeting minutes stored in a shared project file system were available to produce the required evidence.

Relationships: Through more effective conflict resolution and swift progress towards resolution, respondents felt that the overall relationship between business and the IS division may be improved (Respondent 3, 8, 11). Discussions would be unlikely to degenerate into counter-productive blame apportionment. Respondents, however, felt that this required that the practice be mandated, commonly understood and supported by all stakeholders as a pre-requisite.

A recent example was sketched where business leaders distanced themselves from the purchase of a business software application which resulted in conflict and further distrust between the business unit and IS division. In this scenario, however, proof of business participation in requirements gathering was available in emails but a formal decision log and

signatories was not available (Respondent 1). Respondent 1 therefore felt that evidence and traceability of requirements and key decisions were required to drive accountability and avoid costly, time-consuming and counter-productive situations such as these, thereby improving the relationship between IS and its customer base.

Requirements analysis and cost control: Respondent 9 stated that pre-RST will allow analysts to trace and analyse requirements raised by the same individual, an ability that, based on past experience, could be useful for identifying inconsistencies or duplicate requirements. The ability to scrutinise requirements from various perspectives could reduce wasted effort and cost invested in developing solutions for unclear, unapproved or conflicting requirements (Respondent 2). A greater focus on cost scrutiny and control had emerged with the organisation restructure which meant a greater focus on IT and project expenditure (Respondent 2). Pre-RST was viewed as an efficient means of investigating requirements.

"Closing the loop" - Solution validation and acceptance: The ability to routinely provide feedback to business stakeholders was raised as a pre-RST benefit by Respondent 3, stating "*it will help us close the loop (on requirements) which we often don't do, or are not able to do".*

Learning and knowledge transfer: The benefit of learning was not raised by respondents voluntarily. When questioned about this, respondents felt that people usually learnt from their teams and not only through reading documentation as it was often considered unreliable or incomplete. This comment therefore points to the overall reliability and maturity of the requirements management process and outputs. Adding pre-RST to products considered unreliable raises a concern as to whether pre-RST will produce the results required if the underlying maturity is not addressed.

Discussion

Ramesh (1998) distinguished between high end and low end traceability users, with one of the distinguishing factors being their motivations for undertaking traceability. Although the case organisation had not implemented or considered pre-RST, the perceptions from the

respondents regarding the potential value and motivations classified them as potential high-end users. If undertaken, the case organisation would be well-positioned to gain more benefit from pre-RST than if the motivation were compliance, which (Ramesh, 1998) linked to low-end use. Respondents listed various benefits they could foresee from pre-RST but, however, all cautioned that implementation be sufficiently pragmatic for the fast-paced retail industry.

The increase in requests for traceability from business managers as reported by Respondent 5 coincides with the shift in business ownership of business processes and projects, previously largely driven by the IS division (Respondents 5, 8, 10). Business teams reportedly wanted evidence of how requirements came to be and decisions taken. The value of pre-RST may therefore have more resonance within the business community than in the past context, given this drive for ownership. Respondents provided numerous comments regarding the need for increased and sustained business commitment and accountability to projects and requirements, further reinforcing that the timing for pre-RST could be right to contribute towards this. Furthermore, Respondent 1, 2, 10 felt that increased accountability and commitment could lead to more focused and targeted efforts, geared at requirements that business stakeholders remained committed to. The prominence with which accountability and commitment to requirements was raised in this research is consistent with Gotel & Finkelstein (1995's) early research into the requirements traceability problem.

The increase in business requests for evidence and rationale behind decisions may, arguably, also point to a level of distrust that respondents felt pre-RST, if implemented thoughtfully, could contribute towards positively. Pre-RST may therefore offer an opportunity to improve the relationship between the IS division and business as pointed out by various respondents. This is consistent with Jarke (1998) and Regan *et al.* (2012) who listed improved customer relationships as pre-RST benefits. As admitted to by Respondent 3, “closing the loop on requirements” through providing sufficient feedback to requirements stakeholders was not adequately done and could be a benefit linked to pre-RST that ultimately also contributes to improved customer relationships.

Certain respondents felt more value was obtainable from pre-RST in decentralised organisation structures where accountabilities were unclear. This may point to the need for different pre-RST solutions based on the dynamics and structure of the business unit to ensure an appropriate fit. The author did not come across any research related to the impact of organisation structures on the value, type and level of pre-RST schemes, which may highlight an area for future research.

Benefits raised by respondents mostly centred around tracing backwards from requirements to sources with one respondents mentioning the benefit of tracing from sources forward to requirements (Respondent 9). Although only mentioned by one respondent, this shows that broad use of pre-RST was considered without any prompting.

Using traceability for learning and knowledge management was only considered possible if the underlying documentation were reliable. According to the literature, traceability can facilitate integrating new people into projects through supporting learning (Ghazarian, 2008) and organisational knowledge creation (Pohl, 1996). This benefit is reported in the literature as extending beyond the project lifecycle into the maintenance phase, allowing for continuity after team members leave (Ghazarian, 2008). The specific requirement for improving operational service management was raised by Respondent 4.

As raised by respondents 3 and 7, the potential value of pre-RST may only be realised at the end of a project, when it is too late to put something in place. This reinforces the common view in the literature that value-perception is an insurmountable obstacle to successful pre-RST if not proactively and pre-emptively addressed (Arkley & Riddle, 2005). As per CoEst (2014), traceability is often an afterthought on projects which means that pre-RST artefacts can be missed as traces are only established when needed rather than from the start when project artefacts begin to accumulate. Basic awareness, lacking at the case organisation as highlighted in the earlier section, therefore needs to be tackled along with value-perception.

4.4.4 Perceived Challenges

Respondents raised various challenges to overcome for the practice of pre-RST to yield the anticipated benefits. These have been contrasted to the 8 grand challenges compiled through the research conducted by CoEST (Gotel *et al.*, 2012b) with the corresponding challenge as per the literature review displayed in brackets. The challenges raised in the interviews are summarised graphically below.

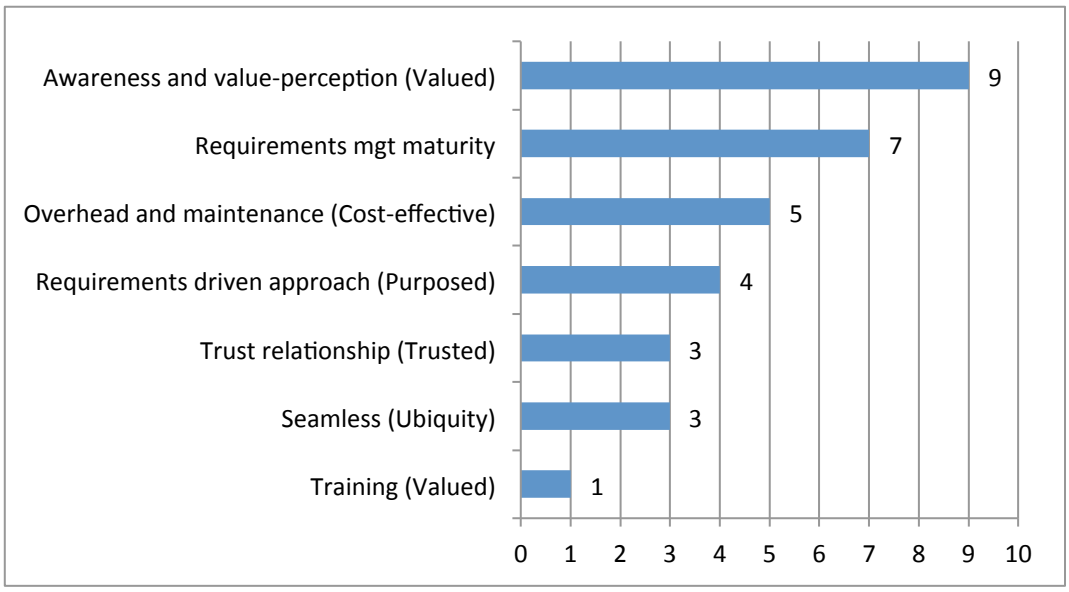

Figure 22: Pre-RST Challenges (Compiled from Research Interviews, 2013)

Awareness and value-perception (Valued): A significant, underpinning challenge to overcome raised by all respondents was awareness and the need for "*buy-in*" (Respondents 2, 3, 5) from all stakeholders as to the benefits delivered by the practice of pre-RST. Consistent with the low levels of awareness raised in the section above, a practice such as pre-RST had never been considered and therefore no formal practice had been put in place (Respondents 2, 3). Furthermore, Respondent 7 referred to traceability as "*a comfort blanket*" often only needed well after the project has been completed, when needing to change solutions, or when projects and decisions are audited "*after the fact*". The value of this "*comfort blanket*" is therefore only realised well after the project:

> "If all goes well then who cares to go back to the first idea, everyone's moved on already. But when things go wrong then people want to go back." (Respondent 7)

Without a clear understanding of the benefits prior to implementation, respondents felt that the practice will be considered bureaucracy and ultimately fail (Respondents 1, 2, 3, 4, 5, 8). To this end, various respondents explicitly raised the need for a well-considered change management programme (Respondents 2, 3, 4, 5, 10) to drive awareness, value-perception and ultimately positive adoption.

> "As long as benefits could be shown, proven, explained, then you will get buy in" (Respondent 3)

Expanding on a potential change management programme, Respondents 2, 3, 4 and 5 mentioned clearly articulating the value proposition to business leaders, requirements providers and analysts responsible for capturing and maintaining traces; and providing adequate training for creation, maintenance and use of traces.

Respondent 3 posed the conundrum that "*benefit follows practice*" warning that it may be difficult to convince stakeholders of the benefits initially until proven through practical application.

> "This is a new concept or terminology being introduced. It must be beneficial as the bottom line. There needs to be buy-in that it'll add value. We have limited resources, money, and delivery time. It must be useful and beneficial to the process. If it can speed up the process, it's easier to buy-in. If it's only seen as a layer of governance to see 'who said what, when' then this is not sufficient value." (Respondent 1)

Respondent 7 reinforced the need for showing that the practice adds sufficient value to warrant its existence.

> "I like structure, governance, processes but you must be pragmatic on what you spend people's efforts on." (Respondent 7)

Awareness and "buy-in" using a method that quickly shows value to stakeholders was therefore raised as the first challenge to overcome. The value proposition therefore needs to be clearly articulated to business leaders, requirements providers and analysts responsible for capturing and maintaining the traces, so as to gain commitment to the practice before implementation.

Although most respondents felt that buy-in to the practice was essential before commencing, the general consensus (Respondents 1, 2, 3, 4, 5, 8, 9, 11) was that business

stakeholders "*don't care about something like this*" (Respondent 4) unless it jeopardises delivery timelines. Minimal business resistance was anticipated if implemented, especially since this involved no additional work from business stakeholders. Regarding potential resistance from business analysts, all business analysts reported that this would be welcomed as a practice that will support and structure their efforts (Respondents 4, 9, 11) especially given "*they are structured individuals by nature*" (Respondent 2).

> "BAs will not hesitate to use this in their documentation" (Respondent 11)

Respondent 10 concurred, adding that practitioners would welcome this as a means to ensure focus is not lost and value shown.

Trust relationships (Trusted): Respondent 11 cautioned that if the practice was implemented in individual projects without an awareness programme as to the reason and benefits of such a practice, that this could damage the relationship between business stakeholders and the business analyst, as the practice may be perceived as motivated by distrust in business input and as a record for apportioning blame at a later stage:

> "The relationship with business is critical and cannot be compromised through documentation that may be interpreted as documenting names to assign blame in future." (Respondent 11)

Additionally, Respondent 5 cautioned that analysts may view pre-RST as a lack of faith in their work and methods, as a "*whipping tool*" and as "*yet another way of checking up on their work*". Respondents 2, 3, 9, 11 disagreed as they felt analysts would welcome such a practice in supporting their efforts to develop requirements. The concern raised by Respondent 5 links in with the political concern raised by Ramesh (1995) that traceability information may be used by management in performance evaluations.

The challenge of "trusted" traceability raised by CoEST (Gotel *et al.*, 2012b) refers to trust in the trace information. The challenge raised by respondents at the case organisation expanded upon this by raising the issue of trust in the intentions behind undertaking traceability and thereby not damaging relationships through a practice perceived as motivated by distrust.

Requirements-driven approach (Purposed): Respondents 1, 2, 3, 7 recommended that careful thought be put into the project issues that pre-RST will address and how pre-RST will support projects so as to base the design of a suitable method on these stakeholder requirements. Such a method should be designed in advance of starting a project and applied consistently across projects (Respondents 5, 8, 11).

Consideration for the industry context was raised by various respondents (Respondent 1, 7, 8, 10). Respondent 7 urged that if implemented, pre-RST practices must be "*pragmatic and simple for retail*". Respondents favoured a simple, practical solution where traces were "*simple to read*" (Respondent 8). This need for pragmatism was highlighted by most respondents with Respondent 7 positioning it as follows:

> "We can't spend too much time and effort on governance and doing things right as opposed to the doing the right things as this may not get you the value." (Respondent 7)

> "We can't afford too much time on bureaucracy. You need to be pragmatic" (Respondent 1)

Retail projects were often driven "*with haste*" as "*speed to market is a major concern*" (Respondent 8). This meant projects "*weren't landed in the best manner*" (Respondent 7, 10), although the need to "*deliver quickly and settle later*" (Respondent 10) was evident in most projects. A major concern is therefore that any pre-RST practice facilitates and expedites, rather than hinders, delivery supported by a clear value proposition for the practice.

Conflicting views emerged on the topic of level of traceability and what was considered pragmatic, with Respondent 8 commenting that the level of documentation may need to vary dependent on the extent of the impact and complexity at hand. Respondents from IS management positions (1, 8) recommended that principle level decisions be traced as traceability at the detailed level may be too much overhead for too little benefit. Respondents from smaller teams, where requirements were sourced from and approved by only one or two representatives, similarly felt they would not benefit from a detailed level of traceability but would benefit from high-level annotations within the BRS listing sources

and rationale. Respondent 5 from the frameworks and governance team, however, disagreed and felt that traceability should be implemented down to the lowest level and consistently across all areas.

Requirements management maturity: Respondents concurred that the requirements management practice itself was immature and inconsistent at the organisation other than in one division, despite inroads made with templates (Respondents 1, 2, 3, 5, 8, 10). Traceability information within and between requirements related documents was lacking as outlined in the earlier section on current practice. Respondents 8, 11 raised the need for a practice such as pre-RST to be uniformly and consistently applied to avoid a situation where the practice was questioned if every project were allowed to operate differently. Respondent 5 agreed that "*all must do it, in the same way"* and that up-skilling will be required to ensure correct and consistent usage. Evidence of immature requirements management came across from two respondents who reported that they did not trust their documentation sufficiently to use for learning and knowledge management purposes, describing the documentation as unreliable (Respondent 2, 3).

The need was therefore raised that the underlying requirements management processes be at a sufficiently mature level with consistent application before embarking upon practices such as pre-RST that respondents felt should be built on top of a solid requirements management foundation (Respondents 1, 2, 3, 5). Respondents felt that requirements elicitation, documentation, naming and numbering be matured and performed consistently across the organisation as a pre-cursor to pre-RST.

> "Requirements management itself first needs to be bedded down before adding something to a foundation that's not settled. It would mean you won't get value from it. Wait for it to settle then add." (Respondent 1)

Respondent 5 expressed concern that practices such as stakeholder analysis was not performed adequately, if at all, by certain business analysts resulting in poor representation in requirements elicitation. Respondent 8 also raised the importance of involving the right people through proper stakeholder identification upfront as amongst the fundamentals to get right.

Regarding developments in the organisation with respect to the concept of RT and pre-RST, Respondent 5 highlighted that the BA framework under development, which is based on the IIBAs BABOK Guide, will drive traceability as one of the mandated requirements management practices. The details of how this would be implemented had not been defined at the time the research was conducted.

Assessing the organisational readiness level for implementing new practices is typically undertaken as part of a change management programme (Anderson & Anderson, 2010: 32) which was raised as essential by most respondents and discussed earlier in this section. Despite concerns raised around the lack of maturity in requirements management practices, Respondent 2, however, commented that the timing for a practice such as pre-RST may be right given the recent organisation restructure, accompanied by tighter scrutiny on expenditure. Requirements and solutions were now questioned much more and no longer accepted as easily which meant that more rigorous requirements management processes were required, making this more valuable. Respondent 3 felt their business unit could "start tomorrow" with a small change to add two attributes within the existing BRS documentation which would introduce minimal overhead and assist their BU. The dependency upon maturity of the requirements management practices (Respondent 1) is therefore questioned when considering the motivation of cost control (Respondent 2) combined with the assertion that more benefit may be obtained from decentralised organisational structures with unclear role accountabilities (Respondents 2, 3).

The maturity level of BA skills was raised as a challenge impacting upon pre-RST. The level of experience and confidence of the BA was raised as a contributing factor to successful implementation of pre-RST by Respondent 9, who felt that BA's were now more experienced than before and were better at challenging instructions from managers and requirements providers. Respondent 2 concurred. This meant that the choice of stakeholders and sources of information would be more actively and confidently questioned rendering pre-RST information more meaningful. The active, optimal use of pre-RST may therefore be dependent on the level of experience and competence of the BA, as the requirements facilitator. The appeal from Aoyama *et al.* (2010) that requirements

practitioners require a guide to learn requirements engineering may prove useful in raising this level of confidence sooner.

Training and Up-skilling (Valued): Respondents 5, 8, 9 raised the need for effective training to ensure consistent application and effective use. Very little to no guidance is available to practitioners for establishing traceability in their projects though (Mader *et al.*, 2009). Aoyama *et al.* (2010) have similarly highlighted the difficulties practitioners experience in learning and practicing requirements engineering in general.

Overhead and maintenance (Cost-effective): Although proclaiming pre-RST as "*instinctively, I know it's important*", respondent 1 was concerned about incurring additional overhead the company could ill afford. Respondent 8 also raised a concern about resources required, as well as the quality of such resources, to capture and maintain pre-RST information. Both the cost and overhead of capturing trace information as well as the effort to maintain such information for it to remain reliable, was raised as a challenge to consider.

Respondent 8 raised considerations related to ownership, maintenance and accessibility in defining a pre-RST scheme, putting forward questions such as:

> "Where do we put it, who looks after it, who owns it, do we know where to find it?" (Respondent 8)

Seamless (Ubiquity): Respondents 1, 3, 7 expressed a preference that pre-RST be seamlessly integrated into underlying requirements management processes. Respondent 1 recommended pre-RST be "*hooked into natural processes and places currently in use in projects*" for it to be sustainable and minimise additional overhead.

> "If this could be achieved with minimal additional overhead and be seen as part of the overall requirements management process, that will be ideal" (Respondent 3).

The consensus from respondents was for pre-RST practices to not add too much overhead or be onerous, with some respondents calling for an automated tool (Respondent 5).

Discussion

Consistent with Regan *et al.* (2012) and Ramesh (1998), challenges raised were primarily organisational and environmental, not technical.

The most significant obstacle to successful pre-RST implementation raised by respondents was that of awareness and value-perception. This reinforces Gotel (2008b's) findings that value-perception posed a fundamental challenge which could undermine traceability efforts. Introducing pre-RST involves additional overhead and cost and therefore, must be understood and supported by all stakeholders and most importantly, "*must show benefit*" (Respondents 1, 2, 3, 5, 7). As reported, the value of this "*comfort blanket*" (Respondent 7) is often only realised towards the end of a project by which time it is too late to consider or implement traceability. The unique contribution, not prominently discussed in literature, was the critical role of a concerted and well-considered change management effort to tackle value-perception. Further research into considerations and recommendations for such a change management effort is suggested.

The vital role of trust between requirements practitioner and provider was raised which extends the challenge reported in the literature from "trusted" traceability information to trust in the intentions behind traceability efforts. The impact of a poorly positioned or understood pre-RST implementation on this relationship of trust has been highlighted.

Further challenges raised were consistent with the research conducted by CoEST (Gotel *et al.*, 2012b). The additional challenge which yielded conflicting input was the level of maturity of requirements management practices as a dependency for pre-RST. Feedback differed in that a few respondents felt a level of maturity was required as a foundation upon which to build pre-RST whereas another respondent felt that a heightened focus on expenditure warranted a practice such as pre-RST to provide the needed transparency around requirements.

The industry context and fast pace of retail was raised by various respondents as a caveat to pre-RST implementations in that speed to market not be compromised. Pragmatism was therefore emphasized by all respondents, consistent with early appeals from (Gotel & Finkelstein, 1995).

CHAPTER 5: SUMMARY AND RECOMMENDATIONS

This chapter presents the conclusions and recommendations from the research against the backdrop of the research problem and research questions pursued.

Research Problem Area

The problem focus area examined in this study can be stated as:

Pre-RST can contribute positively to improved software quality and project success. However, pre-RST is not practiced due to limited awareness and value-perception.

The case organisation did not have any formal or mandated pre-RST in place. Informal, practices were in use and varied across respondents and business units. Awareness of pre-RST was non-existent. Awareness of RT, however, was much more prominent with half of those in requirements analysis roles having in-depth understanding and application of RT with the other half having limited exposure to it.

Pre-RST was considered a "comfort blanket" whose value was only realised towards the end of a project and therefore no thought went into designing for this at the outset of a project when trace capture should commence. The consensus was that pre-RST offers value to projects, primarily in improving business commitment and accountability to requirements, resolving conflict, improving change integration and enabling reuse and continuity on projects despite changes to project teams. The lack of awareness of pre-RST, however, prevented this from having had any form of consideration to date. The need for a well-considered change management programme to tackle awareness and value-perception came through strongly from respondents as a critical success factor for pre-RST implementations.

Research Objectives

The research objectives of this study were to:

1. Investigate both formal and informal pre-RST **practices** employed within the retail IS project setting.

Pre-RST practices were found to be very limited, informal, inconsistent, unwieldy and unreliable at the case organisation, a finding consistent with the expectation in the literature that most companies either do not implement it or implement it in a haphazard manner (Yu, 1997; Ramesh, 1998; Cleland-Huang *et al.*, 2004; Cleland-Huang, 2011; Regan *et al.*, 2012).

Although informal and inconsistent, the majority of respondents had implemented some level of traceability either through personal email archives, workshop notes, or through more structured matrices with numbering and classification systems. These informal practices were not supported by any tools and were generally limited to the name of the requestor on worklogs, the name of the approver on requirements specifications, a list of attendees minuted in workshop notes, relevant dates, and in rare circumstances, the rationale for the requirement, pertinent discussions and decisions. Traceability between documents was not evident as a consistent practice.

2. Determine the level of **awareness** of the concept of pre-RST amongst requirements practitioners and participants.

The experience at the case organisation regarding a lack of awareness and use of the pre-RST is consistent with reports in the literature. Gotel *et al.* (2012c) reported that the term 'traceability' itself was not widely recognised or used in practice despite a level of formal or informal efforts in place to achieve traceability on projects. The case organisation, through the absolute lack of awareness of pre-RST, reinforces the notion amongst researchers that pre-RST is the more neglected aspect of traceability.

The need for pre-RST often occurred towards the end of a project when it was too late to implement a suitable model or approach. This realisation was not carried forward onto subsequent projects resulting in practices remaining informal and inconsistent.

The roles expected to have the most exposure to the term is in the business analysis discipline, namely the business analyst and business delivery manager. Responsibility for requirements management, which encompasses management of the traceability of requirements, is commonly assigned to roles within this discipline as outline by the IIBA (2009). However, 4 of the 7 business analysis roles interviewed had limited or no exposure

to the term. These respondents did not have formal BA qualifications, but had in excess of 8 years' experience in the role. Although not generalisable, this could indicate that the expectation that business analysis roles should be sufficiently familiar with the concept did not hold. This highlights an opportunity for organisational, vocational and academic programmes to reconsider how traceability is designed into courses. As pointed out by Aoyama *et al.* (2010), overall training and practice with respect to requirements engineering was lacking in industry, especially considering that neither requirements analyst nor requirements engineer were established professions. Guidance and a requirements body of knowledge is lacking in the requirements management arena (Mader *et al.*, 2009; Aoyama *et al.*, 2010).

3. Gain insights into **perceptions** from requirements practitioners and participants regarding the value of pre-RST practices.

Although the case organisation had not implemented or considered pre-RST, the perceptions from the respondents regarding the potential value and motivations classified them as potential high-end users. If undertaken, the case organisation would be well-positioned to gain more benefit from pre-RST than if the motivation were compliance, which Ramesh (1998) linked to low-end use.

Benefits ranged from the ability to audit decisions; enable reuse and continuity on projects; to conflict resolution. The prominence with which the benefit of accountability and commitment to requirements was raised in this research is consistent with Gotel & Finkelstein (1995's) early research into the requirements traceability problem. The benefit of tracing from sources forward to requirements, although only mentioned by one respondent, shows that broad use of pre-RST was considered.

The increase in business requests for evidence and rationale behind decisions may, arguably, point to a level of distrust that respondents felt pre-RST, if implemented thoughtfully, could contribute towards positively. It may also be argued that an increase in business ownership for projects and business processes drives an increase in requests for traceability which boosts the value perception from business around pre-RST. However,

considering the perspective of the requirements practitioner, pre-RST may be viewed as more beneficial in decentralised organisation structures where accountabilities are unclear.

This may point to the need for different pre-RST solutions based on the dynamics and structure of the business unit to ensure an appropriate fit. The author did not come across any research related to the impact of organisation structures on the value, type and level of pre-RST schemes, which may highlight an area for future research.

The potential value of pre-RST was only realised at the end of a project, when it is too late to put something in place. This reinforces the common view in the literature that value-perception is an insurmountable obstacle to successful pre-RST if not proactively and pre-emptively addressed (Arkley & Riddle, 2005). As per CoEst (2014), traceability was an afterthought on projects which means that pre-RST artefacts can be missed as traces are only established when needed rather than from the start when project artefacts begin to accumulate.

4. Gain insight into **challenges** to be addressed when considering pre-RST, as perceived by requirements practitioners and participants.

Consistent with Regan *et al.* (2012) and Ramesh (1998), challenges raised were primarily organisational and environmental, not technical. The most significant obstacle to successful pre-RST implementation was that of awareness and value-perception. This reinforces Gotel (2008b) that value-perception posed a fundamental challenge which could undermine traceability efforts. The unique contribution, not prominently discussed in literature, was the critical role of a concerted and well-considered change management effort to tackle value-perception. Further research into considerations and recommendations for such a change management effort is suggested.

The vital role of trust between requirements practitioner and provider was raised which extends the challenge reported in the literature from “trusted” traceability information to trust in the intentions behind traceability efforts. The impact of a poorly positioned or understood pre-RST implementation on this relationship of trust has been highlighted.

Further challenges raised were consistent with the research conducted by CoEST (Gotel *et al.*, 2012b).. The additional challenge which yielded conflicting input was the level of maturity of requirements management practices as a dependency for pre-RST. Feedback differed as to whether this was indeed a dependency or whether business drivers such as a heightened focus on expenditure warranted a practice such as pre-RST to provide the needed transparency around requirements, regardless of the underlying RM practices in place. The question arises as to whether pre-RST could be a trigger for improved RM practices.

The industry context and fast pace of retail was raised by various respondents as a caveat to pre-RST implementations in that speed to market not be compromised. Pragmatism was therefore emphasized by all respondents, consistent with early appeals from Gotel & Finkelstein (1995).

Research Questions

The specific research questions to be addressed may be stated as:

1. *What is the level of awareness and value-perception of pre-RST amongst requirements practitioners and participants?*

Awareness of pre-RST was non-existent amongst requirements practitioners and participants interviewed at the case organisation. Contrary to expectation, not all respondents in analyst roles had had exposure to RT which points to a gap in organisational training or academic or vocational education. The need and value of pre-RST was reported as being realised at the end of a project yet these lessons learnt from previous projects did not seem to filter through to subsequent projects. Lack of awareness meant that pre-RST did not feature in project planning when setting up project systems or governance, and therefore no practices were in place, other than ad-hoc informal documentation which differed in format and extent by individual.

Respondents concurred that pre-RST offered value, largely of an organisational, behavioural and environmental nature, not technical. These ranged from productive conflict resolution;

improved accountability and commitment; more effective change integration; and enabling reuse and continuity beyond project team changes.

2. *What are the challenges to be addressed if considering pre-RST?*

The most commonly raised challenge was that of awareness and value-perception. Respondents highlighted the need for an explicit, concerted change management programme as a critical success factor in this regard. Concerns around maintaining the trust relationship between the requirements practitioner and business requirements provider, and by extension between the IS division and business, were raised and tied back to the need for a change management programme that clarifies the intentions behind pre-RST and thereby address the potential distrust this could signal. The potential for pre-RST to signal distrust in the work of the business analyst was also raised as a consideration.

Challenges raised by respondents, similar to the benefits perceived, were largely of an organisational, behavioural and environmental nature. The key technical consideration related to pragmatism in the approach selected and accessibility and maintenance of traces.

Research Proposition

The research proposition tested in this study can be stated as:

The benefits pre-RST has to offer are not drawn upon due to limited awareness or value-perception of this requirements management technique amongst requirements practitioners or participants.

The proposition above was found to hold true in the case organisation. No awareness or exposure to pre-RST existed and neither was any formal practice mandated or applied. The practice had not been explicitly considered for projects at the case organisation despite experiencing a need for tracing towards the end of a project. Practice therefore remained lacking as these experiences were not carried forward into subsequent projects. Value perception and awareness were raised as the most prominent challenge to address when implementing pre-RST to foster commitment and inspire trust in the intentions behind the practice.

Conclusion

Value perception is the underlying obstacle to overcome for successful pre-RST. The trust relationship both amongst requirements practitioners, and between business stakeholders and requirements practitioners, and by extension the IS division in this case organisation, is dependent upon successfully tackling value perception through clarifying the intentions behind pre-RST.

Recommendations

The evidence suggests that a well-considered change management programme is required to tackle value perception as the foundation for pre-RST. It is important that the trust relationship be carefully considered when implementing pre-RST to ensure it is not compromised.

Suggested further research

Further research into considerations for a change management programme to tackle value perception without compromising the trust relationship may be helpful to organisations preparing to implement pre-RST. Recommendations as to the minimum requirements management foundational practices could be outlined to guide organisations in preparing the environment for pre-RST. The level of, and approach to, tailoring pre-RST based on the organisational structure of the various business units within the organisation also presents an opportunity for further research. A comparative case study on the impact of awareness levels of RT on the project management performance of an organisation may be of further value in determining the role RT plays in project success.

REFERENCES

Ahmad, A and Ghazali, M A (2007) Documenting Requirements Traceability Information for Small Projects. *In*, *IEEE International Multitopic Conference (INMIC)* 28-30 December, Lahore, Pakistan, 1-5.

Anderson, D and Anderson, L A (2010) *Beyond Change Management: How to Achieve Breakthrough Results Through Conscious Change Leadership*. 2nd ed. San Francisco, CA: Pfeiffer.

Aoyama, M, Nakatani, T and Saito, S (2010) REBOK Manifest: Towards a Requirements Engineering Body of Knowledge. *In*, *18th IEEE International Requirements Engineering Conference*, 27 September - 1 October, Sydney, NSW, 383-4.

Arkley, P and Riddle, S (2005) Overcoming the traceability benefit problem. *In*, *13th IEEE International Conference on Requirements Engineering*, 29 August -2 September, 385-9.

Bashir, M F and Qadir, M A (2006) Traceability Techniques: A Critical Study. *In*, *IEEE Multitopic Conference. INMIC '06.*, 23-24 December, Islamabad, Pakistan, 265-8.

Benbasat, I, Goldstein, D K and Mead, M (1987) The case research strategy in studies of information systems. *MIS Quarterly*, **11**(3), 369-86.

Berenbach, B, Paulish, D, Kazmeier, J and Rudorfer, A (2009) *Software and Systems Requirements Engineering*. New York: McGraw-Hill.

Berntsson-Svensson, R and Aurum, A (2006) Successful software project and products: An empirical investigation. *In Proceedings:* Travassos, G H, Maldonado, J C and Wohlin, C (Eds.), *ACM/IEEE international symposium on Empirical software engineering*, Rio de Janeiro, Brazil. ACM, 144-53.

Borg, M, Runeson, P and Ardö, A (2014) Recovering from a decade: a systematic mapping of information retrieval approaches to software traceability. *Empirical Software Engineering*, **19**(6), 1565-616.

Cadle, J, Paul, D and Turner, P (2010) *Business Analysis Techniques: 72 Essential Tools for Success*. Swindon, UK: British Informatics Society Limited.

Castro-Herrera, C (2007) *Towards a Unified Process for Automated Traceability*, Centre for Requirements Engineering, De Paul University.

Cerpa, N and Verner, J M (2009) Why did your project fail? *Communications of the ACM*, **52**(12), 130-4.

Charette, R N (2005) Why software fails [software failure]. *Spectrum, IEEE*, **42**(9), 42-9.

Checkland, P and Holwell, S (1998) *Information, Systems and Information Systems: Making Sense of the Field*. Chichester, UK: John Wiley & Sons.

Cheng, B H C and Atlee, J M (2007) Research Directions in Requirements Engineering. *In*, *Future of Software Engineering, 2007. FOSE '07*, 23-25 May, Minneapolis, MN, 285-303.

Clandinin, D J and Connelly, F M (2000) *Narrative Inquiry: Experience And Story In Qualitative Research*. San Francisco, CA: Jossey-Bass.

Cleland-Huang, J (2005) Toward improved traceability of non-functional requirements. In: *Proceedings of the 3rd international workshop on Traceability in emerging forms of software engineering*, Long Beach, California: ACM, 14-9.

Cleland-Huang, J (2006) Just Enough Requirements Traceability. *In*, *30th Annual International Computer Software and Applications Conference, 2006. COMPSAC '06.* , 17-21 September, Chicago, Illinois, Vol. 1, 41-2.

Cleland-Huang, J (2011) Traceability research: Taking the next steps. In: *TEFSE'11*, Waikiki, Honolulu, HI: ACM, 1-2.

Cleland-Huang, J, Zemont, G and Lukasik, W (2004) A heterogeneous solution for improving the return on investment of requirements traceability. *In*, *12th IEEE International Requirements Engineering Conference*, 6-11 September, Kyoto, Japan, 230-9.

CoEst (cited 2014) *Centre of Excellence for Software Traceability*. [Available online from http://www.coest.org.]

Denzin, N K and Lincoln, Y S, (Eds.) (2005) *The Sage Handbook of Qualitative Research*. Third edn. Thousand Oaks, CA: Sage.

Dubois, H, Peraldi-Frati, M and Lakhal, F (2010) A Model for Requirements Traceability in a Heterogeneous Model-Based Design Process: Application to Automotive Embedded Systems. *In*, *15th IEEE International Conference on Engineering of Complex Computer Systems (ICECCS)*, 22-26 March, Oxford, UK, 233-42.

Eisenhardt, K M (1989) Building Theories from Case Study Research. *Academy of Management Review*, **14**(4), 532-50.

Faily, S, Lyle, J, Paul, A, Atzeni, A, Blomme, D, Desruelle, H and Bangalore, K (2012) Requirements sensemaking using concept maps. *In:* Winckler, M, Forbrig, P and Bernhaupt, R (Eds.), *Lecture Notes in Computer Science*, Vol. 7623, pp. 217-32. Berlin, Germany: Springer.

Finkelstein, A (1991) Tracing back from requirements. *In*, *IEE Colloquium on Tools and Techniques for Maintaining Traceability During Design*, 2 December, London, UK, 7/1-7/2.

Flowers, S (1996) *Software Failure: Management Failure*. *Wiley Series in Software Engineering Practice*, Baffins Lane, Chichester: John Wiley & Sons.

Fontana, A and Frey, J (2005) The Interview: From Neutral Stance to Political Involvement. *In:* Denzin, N K and Lincoln, Y S (Eds.), *The Sage Handbook of Qualitative Research*, pp. 695-728. Thousand Oaks, CA: Sage.

Fortune, J and Peters, G (2005) *Information Systems: Achieving Success by Avoiding Failure*. Cichester, UK: Wiley.

Franz, C R and Robey, D (1986) Organizational context, user involvement and the usefulness of information systems. *Decision Sciences*, **17**(3), 329-56.

Gable, G G (1994) Integrating case study and survey research methods: an example in information systems. *European Journal of Information Systems*, **3**(2), 112-26.

Ghazarian, A (2008) Traceability patterns: an approach to requirement-component traceability in agile software development. In: *Proceedings of the 8th conference on Applied computer scince*, Venice, Italy: World Scientific and Engineering Academy and Society (WSEAS), 236-41.

Glaser, B G and Strauss, A L (1967) *The Discovery Of Grounded Theory: Srategies for Qualitative Research*. Chicago: Aldine.

Glass, R L (2002) *Facts and Fallacies of Software Engineering*. Boston, MA: Addison-Wesley (Pearson Education).

Goodpasture, J C (2002) *Managing Projects For Value*. Vienna, VA: Management Concepts.

Gotel, O, Cleland-Huang, J, Hayes, J H, Zisman, A, Egyed, A, Grunbacher, P and Antoniol, G (2012a) The quest for Ubiquity: A roadmap for software and systems traceability research. *In*, *20th IEEE International Requirements Engineering Conference*, 24-28 September, Chicago, IL, 71-80.

Gotel, O, Cleland-Huang, J, Huffman Hayes, J, Zisman, A, Perez-Egyed, A, Grünbacher, P, Dekhtyar, A, Antoniol, G, Maletic, J and Mäder, P (2012b) The Grand Challenge of Traceability (v1.0). *In:* Cleland-Huang, J, Gotel, O and Zisman, A (Eds.), *Software and Systems Traceability*, pp. 343-409: Springer.

Gotel, O, Cleland-Huang, J, Huffman Hayes, J, Zisman, A, Egyed, A, Grünbacher, P, Dekhtyar, A, Antoniol, G, Maletic, J and Mäder, P (2012c) Traceability Fundamentals. *In:* Cleland-Huang, J, Gotel, O and Zisman, A (Eds.), *Software and Systems Traceability*, pp. 3-22: Springer.

Gotel, O C Z (2008a) Tracing Whodunit. *In*, *3rd International Workshop on Multimedia Requirements Engineering: Beyond Mere Descriptions and with More Fun and Games (MERE 2008)*, 9 September, Barcelona, Spain, 27-31.

Gotel, O C Z (2008b) Traceability – Problems in a Word. *Requirements Quarterly 49, The Newsletter of the British Computer Society Requirements Engineering Specialist Interest Group (RESG)*, **October**.

Gotel, O C Z and Finkelstein, A C W (1994a) Modelling the Contribution Structure Underlying Requirements. *In*, *1st International Workshop on Requirements Engineering: Foundation of Software Quality (REFSQ 1994)*, 6-7 June, Utrecht, The Netherlands, 71-81.

Gotel, O C Z and Finkelstein, A C W (1994b) An analysis of the requirements traceability problem. *In*, *First International Conference on Requirements Engineering*, 18-22 April, Colorado Springs, CO, 94-101.

Gotel, O C Z and Finkelstein, A C W (1995) Contribution Structures. *In*, *2nd IEEE International Symposium on Requirements Engineering (RE 1995), IEEE Computer Society Press*, York, UK, 100-7.

Gotel, O C Z and Finkelstein, A C W (1997) Extending Requirements Traceability Through Contribution Structures. In: [Online] Available from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.132.6525&rep=rep1&type=pdf.

Gotel, O C Z and Morris, S (2011) Requirements Tracery. *Software, IEEE*, **28**(5), 92-4.

Hamel, J, Dufour, S and Fortin, D (1993) *Case Study Methods*. Newbury Park, CA: Sage.

Hartman, F and Ashrafi, R (2002) Project management in the information systems and information technologies industries. *Project Management Journal*, **33**(3), 5-15.

Heindl, M and Biffl, S (2005) A case study on value-based requirements tracing. *In*, *Proceedings of the 10th European software engineering conference held jointly with 13th ACM SIGSOFT international symposium on Foundations of software engineering*, 5-9 September, Lisbon, Portugal. ACM, 60-9.

Ingram, C and Riddle, S (2012) Cost-Benefits of Traceability. *In:* Cleland-Huang, J, Gotel, O and Zisman, A (Eds.), *Software and Systems Traceability*, pp. 23-42: Springer London.

International Institute of Business Analysis (2009) *A Guide To The Business Analysis Body Of Knowledge (BABOK Guide) v2*. International Institute of Business Analysis. [Online] Available from: http://www.iiba.org/babok-guide/babok-guide-v2.aspx.

Jarke, M (1998) Requirements tracing. *Communications of the ACM*, **41**(12), 32-6.

Jonasson, H (2008) *Determining Project Requirements*. *ESI International Project Management Series*, Boca Raton, FL: Auerbach.

Jureta, I and Faulkner, S (2007) Tracing the Rationale Behind UML Model Change Through Argumentation. *In:* Parent, C, Schewe, K-D, Storey, V and Thalheim, B (Eds.), *Conceptual Modeling - ER 2007*, Vol. 4801, pp. 454-69: Springer Berlin Heidelberg.

Kappelman, L A, McKeeman, R and Zhang, L (2006) Early warning signs of IT project failure: The dominant dozen. *Information Systems Management*, **Fall**, 31-6.

Kelly, S (2010) Towards an evolutionary framework for agile requirements elicitation. In: *Proceedings of the 2nd ACM SIGCHI symposium on Engineering interactive computing systems*, Berlin, Germany: ACM, 349-52.

Klein, H K and Myers, M D (1999) A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly*, **23**(1), 67-94.

Lee, A S and Baskerville, R L (2003) Generalizing Generalizability in Information Systems Research. *Information Systems Research*, **14**(3), 221-43.

Lee, C, Guadagno, L and Jia, X (2003) An Agile Approach to Capturing Requirements and Traceability. *In*, *2nd International Workshop on Traceability in Emerging Forms of Software Engineering*, 7 October, Montreal, Canada.

Liang, P, Avgeriou, P, He, K and Xu, L (2010) From collective knowledge to intelligence: pre-requirements analysis of large and complex systems. *In*, *1st Workshop on Web 2.0 for Software Engineering (Web2SE'10)*, 4 May, Cape Town, South Africa. ACM, 26-30.

Lyytinen, K and Robey, D (1999) Learning failure in information systems development. *Information Systems Journal*, **9**(2), 85-101.

Mader, P and Egyed, A (2012) Assessing the effect of requirements traceability for software maintenance. *In*, *28th IEEE International Conference on Software Maintenance (ICSM)*, 23-28 September, Trento, Italy, 171-80.

Mader, P, Gotel, O and Philippow, I (2009) Motivation Matters in the Traceability Trenches. *In*, *17th IEEE International Requirements Engineering Conference (RE '09)* 31 August - 4 September, Atlanta, GA, 143-8.

Merriam, S B (2009) *Qualitative Research: A Guide to Design and Implementation*. San Francisco: Jossey-Bass.

Miles, M and Huberman, A (1994) *Qualitative Data Analysis: An Expanded Sourcebook*. 2nd ed. London: Sage.

Monk, A and Howard, S (1998) The rich picture: A tool for reasoning about work context. *Intewractions*, **March & April**, 21-30.

Morris, P and Pinto, J K (2007) *The Wiley Guide to Project, Program, and Portfolio Management*. Hoboken, NJ: John Wiley & Sons.

Morris, P W G (2010) Research and the future of project management. *International Journal of Managing Projects in Business*, **3**(1), 139-46.

Mouton, J (2001) *How To Succeed In Your Master's And Doctoral Studies : A South African Guide And Resource Book*. Pretoria: Van Schaik.

Myers, M D (1997) Qualitative research in information systems. *MIS Quarterly*, **June**, 241-2.

Naqvi, A and Hyder, S I (2007) End-to-End Requirement Traceability through Contribution Structures and Requirements Traceability Matrices. *Technology Forces Journal of Engineering and Sciences*, **1**(1), 1-7.

Nicholas, J M and Steyn, K (2008) *Project Management for Engineering, Business and Technology*. Third ed. Oxford, UK: Butterworth-Heinemann.

Nuseibeh, B and Easterbrook, S (2000) Requirements engineering: a roadmap. *In*, *Conference on The Future of Software Engineering*, 4-11 June, Limerick, Ireland. ACM, 35-46.

Orlikowski, W J and Baroudi, J J (1991) Studying Information Technology in Organizations: Research Approaches and Assumptions. *Information Systems Research*, **2**(1), 1-28.

Panis, M C (2010) Successful Deployment of Requirements Traceability in a Commercial Engineering Organization...Really. *In*, *18th IEEE International Requirements Engineering Conference*, 27 September - 1 October, Sydney, NSW, 303-7.

Panis, M C and Pokrzywa, B (2007) Value-Based Requirements Traceability: Lessons Learned. *In*, *15th IEEE International Requirements Engineering Conference*, 15-19 October, Delhi, India, 115-8.

Pinheiro, F A C (2004) Requirements Traceability. *In:* Sampaio Do Prado Leite, J C and Doorn, J H (Eds.), *Perspectives on Software Requirements*: Kluwer Academic.

Pinto, J K (2007) *Project Management: Achieving Competitive Advantage*. Upper Saddle River, NJ: Pearson Education.

Pohl, K (1996) PRO-ART: enabling requirements pre-traceability. *In*, *Second International Conference on Requirements Engineering*, 15-18 April, Colorado Springs, CO, 76-84.

Project Management Institute (2014) *Requirements Management: A Core Competency for Project and Program Success*, [Online] Available from: http://www.pmi.org/~/media/PDF/Knowledge Center/PMI-Pulse-Requirements-Management-In-Depth-Report.ashx: Project Management Institute.

Project Management Institute (2015) *Business Analysis For Practitioners: A Practice Guide*. Newtown Square, PA: Project Management Institute.

Punch, K F (2005) *Introduction To Social Research: Quantitative and Qualitative*. 2nd ed. London: Sage.

Raja, U and Kamran, K (2008) *Framework for Requirements Traceability - TLFRT supporting pre-RS and post-RS traceability*, School of Engineering, Blekinge Institute of Technology.

Ramesh, B (1995) Traceability in Model Lifecycle Management. *In*, *ISDSS '95 Conference*, July, Hong Kong, 295-303.

Ramesh, B (1998) Factors influencing requirements traceability practice. *Communications of the ACM*, **41**(12), 37-44.

Ramesh, B and Edwards, M (1993) Issues in the development of a requirements traceability model. *In*, *IEEE International Symposium on Requirements Engineering*, 4-6 January, San Diego, CA, 256-9.

Ramesh, B and Edwards, M (1995) Towards Models for Requirements Traceability. *In*, *IEEE International Symposium on System Engineering of Computer Based Systems*, March, Tucson, AZ, 229-32.

Ramesh, B and Jarke, M (2001) Toward reference models for requirements traceability. *IEEE Transactions on Software Engineering*, **27**(1), 58-93.

Ramesh, B, Cao, L and Baskerville, R (2010) Agile requirements engineering practices and challenges: an empirical study. *Information Systems Journal*, **20**(5), 449-80.

Ravichandar, R, Arthur, J D and Pérez-Quiñones, M (2007) Pre-Requirement Specification Traceability: Bridging the Complexity Gap through Capabilities. *In*, *TEFSE/GCT'07*, 22-23 March, Lexington, KY.

Regan, G, McCaffery, F, McDaid, K and Flood, D (2012) Traceability-Why Do It? *In:* Mas, A, Mesquida, A, Rout, T, O'connor, R and Dorling, A (Eds.), *Software Process Improvement and Capability Determination*, Vol. 290, pp. 161-72: Springer Berlin Heidelberg.

Rempel, P, Mader, P and Kuschke, T (2013) An empirical study on project-specific traceability strategies. *In*, *21st IEEE International Requirements Engineering Conference*, 15-19 July, 195-204.

Riessman, C K (1994) *Qualitative Studies In Social Work Research*. Thousand Oaks, CA: Sage.

Sampaio do Prado Leite, J C and Oliveira, A P (1995) A client oriented requirements baseline. *In*, *Second IEEE International Symposium on Requirements Engineering*, 27-29 March, York, UK, 108-15.

Savolainen, P, Ahonen, J J and Richardson, I (2012) Software development project success and failure from the supplier's perspective: A systematic literature review. *International Journal of Project Management*, **30**(4), 458-69.

Schultze, U (2000) A confessional account of an ethnography about knowledge work. *MIS Quarterly*, **24**(1), 3-41.

Serrano, M and Sampaio do Prado Leite, J C (2011a) A Rich Traceability Model for Social Interactions. *In*, *TEFSE'11*, 23 May, Waikiki, Honolulu, HI, USA, 63-6.

Serrano, M and Sampaio do Prado Leite, J C (2011b) A Social Interaction Based Pre-Traceability for i* Models *In Proceedings:* Castro, J, Franch, X, Mylopoulos, J and Yu, E (Eds.), *iStar 2011 - 5th International i* Workshop*, 28-29 August, Trento, Italy, 132-7.

Stake, R E (1995) *The Art Of Case Study Research*. Thousand Oaks, CA: Sage.

Stepanian, L S (2004) *Solving the Requirements Traceability Problem: A Comparison of Two Pre-Requirements Specification Traceability Enablers*, Toronto: Computer Systems Research Group, University of Toronto.

Tang, A, Jin, Y and Han, J (2007) A rationale-based architecture model for design traceability and reasoning. *Journal of Systems and Software*, **80**(6), 918-34.

Toranzo Céspedes, M A, Cysneiros Filho, G, Gómez, Y and Rodríguez Mendoza, O (2012) Towards a framework for improving requirement traceability. *Ingeniería e Investigación*, **32**(1), 48-52.

Verner, J M and Evanco, W M (2005) In-house software development: what project management practices lead to success? *Software, IEEE*, **22**(1), 86-93.

Wieringa, R J (1995) Combining static and dynamic modelling methods: A comparison of four methods. *The Computer Journal*, **38**(17-30).

Williams, D W, Hall, T and Kennedy, M (1999) A framework for improving the Requirements Engineering process management. *Software Quality Journal*, **8**(2), 133-47.

Williams, T M (1999) The need for new paradigms for complex projects. *International Journal of Project Management*, **17**(5), 269-73.

Xia, W and Lee, G (2004) Grasping the complexity of IS development projects. *Communications of the ACM*, **47**(5), 68-74.

Yin, R (1994) *Case Study Research: Design and Methods*. 2nd ed. Thousand Oaks, CA: Sage.

Yin, R (2003) *Case Study Research: Design and Methods*. 3rd ed. Thousand Oaks, CA: Sage.

Yin, R (2009) *Case Study Research: Design and Methods*. 4th ed. Thousand Oaks, CA: Sage.

Young, R R (2004) *The Requirements Engineering Handbook*. Norwood, MA: Artech House.

Yu, E S K (1997) Towards modelling and reasoning support for early-phase requirements engineering. *In*, *Third IEEE International Symposium on Requirements Engineering*, 6-10 January, Annapolis, MD, 226-35.

APPENDIX

Appendix 1: GLOSSARY OF TERMS

Pre-Requirements Specification Traceability	***Pre-RST*** *refers to those aspects of a requirement's life prior to its inclusion in the requirements specification (RS) (Gotel & Finkelstein, 1994b).*
Post-Requirements Specification Traceability	***Post-RST*** *refers to those aspects of a requirement's life that result from inclusion in the requirements specification (RS) (Gotel & Finkelstein, 1994b).*
Requirement	*A requirement is*: *(1) A condition of capability needed by a stakeholder to solve a problem or achieve an objective.* *(2) A condition of capability that must be met or possessed by a solution or solution component to satisfy a contract, standard, specification, or other formally imposed document.* *(3) A documented representation of a condition of capability as in (1) or (2).* *(International Institute of Business Analysis, 2009)*
Requirements Management	*The process whereby requirements are defined and managed over the course of a project (Williams et al., 1999)*
Requirements Specification	*The formal document that outlines the requirements statements.*
Requirements Traceability	*The ability to describe and follow the life of a requirement, in both a forwards and backwards direction (i.e. from its origins, through its development and specification, to its subsequent deployment and use, and through all periods of on-going refinement and iteration in any of these phases (Gotel & Finkelstein, 1994b).*
Requirements Tracing	*The activity of either establishing or using traces (Gotel et al., 2012c).*

Appendix 2 – Summary of Interviews

Summary of Interview 1

Participant A, Friday 22 Nov 2013, 3.30 - 4.45pm

PART A – DEMOGRAPHICS/BACKGROUND

Yrs Service at PnP: 3yrs+ **Yrs Service in IS/Retail/Other:** 18yrs+

Department: Info Services **Position:** Head of Solution Delivery & Governance

Role wrt Requirements Development:

- In current position responsible for a range of competencies, namely Enterprise Architecture; Innovation; IS Governance; Testing/Quality Assurance; Project Management; Business Analysis and Change Management; Strategic vendor engagements. Role includes development and governance of frameworks to improve IS and project processes, delivery and overall maturity.
- Until recently, responsibility included Technical Solution Delivery (application development and infrastructure). Role therefore included solution development and delivery across projects once requirements are signed off.
- Sponsor for IS Technical projects (e.g. IT Security, Identity Management, Improved e-communication, E-mail upgrade, etc.), providing and signing off requirements for IT improvements. Not at "coalface of gathering requirements" as this is done by the resources within the teams.

Background:

- Roles: developer, analyst, project management, systems and IT management
- Experience in IT for more than 18 years; 3 years at PnP; prior to that in another large retailer.

Projects:

- Current focus is on Identity management, a small project in terms of resourcing with impact being on HR processes (hire to retire process); IS productivity tools; Email upgrades; IT Security; COBIT implementation. Projects range from small to large, low to high impact, minor to broad organisational impact.

PART B – AWARENESS

Terminology:

- Neither RT nor Pre-RST is in use in organisation. No alternate term. Terms not heard in any organisation in participant's experience in IT/projects.

Concept:

- Concept of RT and Pre-RST "*makes sense*" as something that can enhance project processes but has not been considered in the "*real world*".

PART C – CURRENT PRACTICE

Ability to trace requirements:

- *"Yes, we can probably trace to original sources or to a group of people, but not easily"*. Usually, teams work with specific stakeholders in specific area and would need to gather and sign off requirements during the project lifecycle which the PM is meant to ensure and track. Not doing this consistently. Can get to requirements in some form but not consistent.
- The organisation is not in a mature state to be able to do this especially if requirements were sourced in a workshop it's not easy to pinpoint the exact individual.
- In general, it's possible to pinpoint the source of a requirement where the organisation structure is mature by virtue of well-defined structures and clear roles and responsibilities. It's easier to track back in more mature departments (where business users take ownership and won't dispute who contributed/owns requirements when they need to change).
- Conversely, tracking down originators or contributors becomes difficult in areas where the structure is unclear or immature and roles are not well defined or fulfilled. Exacerbated by constantly changing requirements where multiple parties add to a constantly changing set of requirements and landscape. If not clear on R&R then therein lies a problem with traceability - people not following right processes/templates; various things cause this to be problematic; difficult to come in half way to understand context amidst unclear R&R in retail specifically difficult as requirements change far quicker, in a less rigid way.
- Tracing becomes more difficult for larger projects with broader stakeholder base.
- Trace information (meta-requirements information) may be kept in a dispersed way, based on what individuals have documented or kept. It won't be easy to find.

Traceability tools/techniques employed, mandated (and extent of use):

- No tools mandated or in use. Trace information is limited to informal, inconsistently captured or applied (no template/approach), unstructured and scattered/dispersed correspondence in emails, in workshop or meeting minutes and notes.
- Maturity levels not there as yet for this to be an organisation practice. Working on putting in place more consistent ways of documenting requirements.

What trace info exists between pre-RST documents/artefacts such as business vision and BRS:

- Inconsistent application of documentation especially business case documents which is not uniformly compiled.

Requirements Management:

- Requirements management practices are inconsistent across the organisation. In certain areas where organisation is more mature in its structure and ways of working (and focus defined/clear/singular), documentation will be more readily available, better structured and more consistently used.
- Different departments at different levels of maturity wrt requirements management. Not documenting requirements consistently. Will be able to get to requirements but may be in different formats (Word, Email, PowerPoint).
- Base RM process is receiving focus within the BA Framework under construction and due to be implemented in 2014. RT can be considered on the back of RM improvements but first need to get basic RM in place, uniformly. *"Structural divide coming to drive an improved process and disciplines."* (BA area vs Bus areas vs Sol areas…?)
- The aim of more mature RM processes is to (at least) have sign off of requirements so as to drive accountability.
- ***Example***: A business area demanded an improved planning tool as requirement. Requirements and decisions were signed off. Tool subsequently rejected when decision/choice called into question by new senior leaders. No accountability forthcoming from business for this decision – "blame" left to IS department for the decision. Records of sign-off exist so in this case documented traceability back to decision makers did not assist.
- Maturity and ownership of person/area asking for requirements and happy to sign off.

Project issues due to poor pre-RST:

- Ownership
- Invalid/unimportant requirements pursued to discover later that it's not really needed.
- If goes well, people happy to put up their hands but if called into question then IT/another dept is blamed. *Role of IT vs business raised by this example – decision challenged and overturned by senior leaders; thereafter no-one taking ownership for decision; blaming IT for taking decision. IT's role was to facilitate decision. Business participated in decision and signed off.
- *"Projects are often based on ideas and it's not always possible to trace to these originating ideas."* As a result, solutions could vary significantly from the original requirement especially where originators do not take full ownership for an idea and project processes are not followed to clarify requirements before proceeding into development or implementation in order to satisfy senior leaders and expedite delivery. Projects are often driven by deadlines, defined at time idea is raised, which results in insufficient upfront requirements definition and clarification and insufficient business/user involvement at times.

PART D – PERCEPTION

Importance of being able to trace a requirement to its source contributions:

- *"My immediate reaction is yes as it would be useful, but in practical and pragmatic way"*
- If goes well then who cares to go back to first idea; everyone's moved on already; but when things go wrong then people want to go back

- *"Can't spend too much time and effort on governance and doing things right as opposed to right things as this may not get you the value"*
- As part of ASAP methodology, SAP has level 0 questions/requirements – this would be useful to have traceability on; principle discussions and decisions; can answer why we made certain decisions as these may be questioned to be able to move on e.g. why did we make certain decisions around a financial process. In some areas, going back to the original requirement could take longer than making the change itself.
- Example – idea between two leaders moved to implementation. Requirements not documented, most likely informal emails, original requirement and rationale lost, idea has completely changed due to barriers. Useful to have traceability in such examples
- In idea phase would be useful to have traceability at principle level
- More people involved later in project and lower level of detail – as go down requirements, you need to build solution. If things go well don't need to go down to detailed level but ultimately must be pragmatic, easily captured and accessible to go back to else trawl through reams of information and people get lost in this process. Need to question if it's worth it. I like structure, governance, processes but you must be pragmatic on what you spend people's efforts on. Doing the right things vs doing things right…there's a fine balance between that.

What type of traceability scheme would work for your organisation?

- Must be pragmatic, practical *(value-adding, cost efficient, not onerous)*
- Apply same process or framework if going to apply something

Benefits (benefits currently achieved/sought from pre-RST practices):

- Go back to requirements and level 0 principles ;understand context of where came from will inform future
- More committed sponsor/requirements giver: Better workflow/use to time from more deliberate processes to link back to source and not assume they wanted this as a real requirement – could've struck it off as bad idea after originally tabled briefly and informally
- Change impact analysis

Motivations (why would you implement pre-RST at your organisation?):

- Go back to sponsors/ideas/principle team so as to avoid embarking on work not thoroughly validated

Challenges to implementing pre-RST:

- Organisation is at different maturity levels. Normal gathering of requirements still not mature. RM itself first needs to be bedded down before adding something to a foundation that's not settled would mean won't get value from it. wait for settle then add
- Value perception especially with analyst community (those that need to do the work of capturing and maintaining traces); business community not phased as they won't do the work

- Org structure maturity affects how easily people accept / commit to requirements
- Think person impacted that's doing the work will be resistant – most resistance will be from people that need to work within the framework, follow additional steps
- Need to upskill people on framework, using templates correctly and consistently. It's an added layer of governance.
- Buy in: Need to sell benefit to whoever will be doing it and business owners to sign off on this. Will need change mgt to sell benefits of adding a layer of governance. Need to understand benefit clearly – to business and to people working within process.
- How to buy in - Need to work it into the process, must be relevant, can always refer to ; hook into natural processes and places currently in use in projects.

Closing Comments:

- *"This is a new concept or terminology being introduced. Must be beneficial as bottom line. Need to buy in that it'll add value. Ltd time, resource, money, delivery time. Must be useful and beneficial to process. If can speed up process, easier to buy in. If only seen as layer of governance to see who said what when then not sufficient value."*

Appendix 3 – Letter to Participants

Dear <participant>,

I am conducting research into the requirements management practice known as requirements traceability. The aim is to explore how organisations trace requirements from, and back to, their origins. I would like to invite you to participate in the research project. I am interested to find out about your experiences in contributing to the development of requirements in projects in your organisation. I want to understand how links between business and stakeholder needs are carried forward into requirements documentation. I would like to interview people who have been involved in the requirements definition process.

The interview will be an informal interview with a few core questions I'd like your feedback and insights into. The interview should be approximately 1 hour long and will be voice recorded and transcribed afterwards for analysis. Please confirm whether you approve of recording the interview.

Information gathered from the interviews will be treated as confidential and the source will only be known to the principal researcher. Your identity will not be linked to the input you provide. The research paper will refer to the case study site as "Organisation A" and each participant will similarly be referenced anonymously, for example as "Respondent A". The interview information will be collated into a case study report. You may receive a copy of the summarised report.

Please understand that your participation is voluntary. If you choose not to participate, there will be no negative consequence. If you choose to withdraw at any time, you will be free to do so without negative consequence. However, I would be grateful if you would assist me by allowing me to interview you.

Thank you in advance for your participation. Your insights and experiences shared in the interviews will play a critical role in the success of this study.

Kind regards, Jeandré Williams

CONSENT FORM:

I, _____ (print name), am fully aware of the aim, motivation, and purpose of this study and_____ (disagree/agree), to participate in this study. I understand that the organisation and participants will be treated as anonymous and no specific reference will be made to either the organisation or the individual participants identities.

SIGNED AT _____ ON THIS THE _____ DAY OF _____

PARTICIPANT: _____

Appendix 4 – CoEST Research Directions

The Quest for Ubiquity: A Roadmap for Software & Systems Traceability Research

Challenges

Σ Valued: Strategic priority (buy-in & commitment to implementation)
P Purposed: Requirements-driven & fit for purpose (prototypical profiles & patterns)
↔ Portable: Exchanged, merged & reused (unified policies, standards & language)
 # Scalable: Through-life & cross-boundary (levels of abstraction & granularity)

Research Themes

$ Cost-effective: Return is adequate in relation to outlay (cost-benefit models for analysis)
∀ Configurable: Compliant with changing needs (semantically-rich dynamic specifications)
T Trusted: Of dependable quality (systematic quality assessment & assurance)
∞ Ubiquitous: Always there when needed (integral to broader processes & tool support)