THE IRONY OF COAL MINING INFRASTRUCTURE PROJECTS: THE MORE TALK ABOUT COST, THE MORE THEY COST.

A Thesis submitted by

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ABSTRACT

A substantial amount of mining infrastructure projects experience cost and schedule overruns, and this situation is largely brought about by poor requirements management. More specifically, evidence suggests that overruns are primarily due to inadequate requirements definition and scoping, as well as the poor handling of requirements information throughout the project lifecycle.

With many parallels to mining infrastructure, the construction management literature agrees that there are some common compromising conditions associated with poor requirements management: clients are not fully engaged in the requirements gathering/identifying process; client's requirements are not properly elicited, identified and captured; decisions made about requirements specifications are solution biased by partisan factions; manual requirements documentation suffers from version control; and the end user's identification and involvement is usually too late.

Of concern to the mining industry and their infrastructure projects, is that the implications of cost and schedule overruns is significant, to the extent that on average cost overruns can be 95% above the original estimate. This suggests that for the mining industry, overrunning the sanctioned budget and schedule commitments are a regular occurrence. Therefore, the research problem for this study is to the explore requirements management conditions and establish the subsequent contributing factors in mining infrastructure projects that persistently makes them vulnerable to costly overruns.

This research was divided into two stages, with Study 1 exploring the comprising conditions in requirements management, which subsequently informed Study 2 to establish the contributing factors. This study used semi-structured interviews and some internal documentation reviews to develop a theory to explain why the situation is not improving for mining infrastructure projects. Interview data was collected from a cross-section of professionals currently in owner teams, consulting, and delivering infrastructure projects in the Australian Coal Mining industry. The results of a thematic analysis on interview transcripts finds the claims of the previously identified compromising conditions of construction projects to also be true of mining infrastructure projects, with the additional compromising conditions

of ‘late changes to projects by new stakeholders’, which may be peculiar to mining infrastructure projects.

However, more pertinently to the development of a theory to explain the situation, a second round of analysis and coding on the transcripts and documentation applied with a Husserlian lens revealed that the requirements management documentation was not fit for purpose, in terms of how it is dominated by exchange-value and fails to adequately capture the use-value and benefits of the project.

The terms exchange-value is defined as the monetary amount realized at a certain point in time, whereas use-value refers to the specific qualities of the product perceived by customers in relation to their needs, which for example could be functionality. The preferencing of exchange-values is considered a result of the influence of management discourse. This discourse is evident in the requirements documentation that management sanction. However, in the interviews, participants appeared to feel less pressured or bound to adopt the management discourse. As many of them are mining engineers or engineering/mining workers who have moved into management roles, they tend to speak in terms of use-value (a things ability to satisfy a need) as well as exchange-value (the price or cost of production).

The findings of this study include the determination of an additional compromising condition to requirements management, which is that of late changes by new stakeholders. Another finding is that a contributing factor to cost and schedule overruns in mining infrastructure projects is the misalignment of values inculcated in requirements management documentation, which privilege the values of management (exchange-value) rather than the values of the client and end-users (use-value).

Whilst these documents and processes are intended to describe, convey, and ultimately safeguard the project’s use-value for the client through to delivery, management is largely the consumers of these documents, and they have unwittingly biased these documents to communicate exchange-value. Furthermore, the exchange-value biased requirements management documentation, influences the processes and discourse around the project, and consequentially marginalizes use-value discourse, which ironically in the long run, drastically increases the cost of the project.

CERTIFICATION OF THESIS

This Thesis is entirely the work of Benjamin Skerman except where otherwise acknowledged. The work is original and has not previously been submitted for any other award, except where acknowledged.

Principal Supervisor: Associate Professor Stephen J Whitty

Associate Supervisor: Dr Bronte Van Der Hoorn

Student and supervisors' signatures of endorsement are held at the University.

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In loving memory of Joan Sankey, Kenneth Taylor, Karen Warnock, Irene Bombas and Marc Pinter.

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LIST OF ABBREVIATIONS

Abbreviation	Definition
KPI	Key Performance Indicators
KRA	Key Performance Indicators
NPV	Net Present Value
ROCE	Return on Capital Employed
RBA	Reserve Bank of Australia
SoR	Statement of Requirements

GLOSSARY OF TERMS

Term	Definition
Capital Productivity	a measure of the effectiveness and efficiency of capital investments in generating operational outputs
Exchange-value	the monetary amount realized at a certain point in time, when the exchange of the new task, good, service, or product takes place, or the amount paid by the user to the seller for the use-value of the focal task, job, product, or service
Stakeholder Value	the subjective judgment of a stakeholder, occurring at the individual level, of the total monetary and non-monetary utility experienced as a result of some decision or action by an organization
Use-value	the specific qualities of the product perceived by customers in relation to their needs
Value Management	a structured and analytical process which follows a prescribed Work Plan to achieve the best value for money

CHAPTER 1: INTRODUCTION

1.1 Introduction

Mining infrastructure projects are about developing and constructing something that provides some benefit in the mining industry after its instatement. As well as simply reducing cost or increasing profit, the desired benefits could be to improve or expand functionality; to improve quality, safety, or usability; to enter new markets, to improve efficiency in terms of eliminating the unnecessary, reducing over-engineering, eliminate redundancy and loss of energy; to solve chronic problems with a novel solution; or to harvest true and accurate data/information for better decision making.

However, investment capital in the Australian coal-mining expenditure investment has significantly reduced from 2012 and is expected to further decline (RBA 2016), which has resulted in reduced capital investments across the global mining industry (EY 2015). Issues leading to this reduction in capital investment highlight the importance of maximising project value and eliminating project shortcomings and failures in an environment where reduced funding is available to achieve the business strategy. In terms of project failures, EY (2015, p.3) identified that 'every overrun impacts total shareholder return, Return on Capital Employed (ROCE), capital productivity, corporate performance and strategic outcomes'. Maximizing project value is essential in order to achieve capital productivity, which is defined as 'a measure of the effectiveness and efficiency of capital investments in generating operational outputs' (EY 2015, p. 5). In short, capital productivity assesses "value for money" on a multibillion dollar scale' (EY 2015, p. 5) with the intent to achieve more with less through a minimal payback period and a high Net Present Value (NPV).

Furthermore, extant literature into mining projects reveal that cost and schedule overruns are a regular occurrence (EY 2015; Hart et al. 2013; KPMG 2015; Lwin & Lazo 2016; Singh 2010; Walker 2015). This research reviews this phenomenon of overruns and develops a theory to explain why the situation is not improving for mining infrastructure projects. This research was completed in two study stages as follows:

- **Study 1** – investigate requirements management and determine the existence of any comprising conditions

- **Study 2** – Investigate value with respect to privileging of either exchange-value or use-value

This research was divided into two stages and is linked by exploring comprising conditions in requirement management that leads to poor mining infrastructure project outcomes in Study 1 with the key emerging theme used to inform Study 2. The key theme that emerged from Study 1 was the use of the term value in requirements management documentation that resulted in project overruns.

Study 1 research was completed by semi-structured interviews, with data collected from a cross-section of professionals in owner teams, consulting, and delivering infrastructure projects in the Australian Coal Mining industry. The purpose of the interviews was to enable a broad discussion on requirements management across the project lifecycle in coal mining infrastructure construction project. By exploring each lifecycle component further, these questions generated detailed discussion and an understanding of requirements management. The results of study 1 identified the existence of compromising conditions in requirements management, with 5 of the 6 conditions existing in construction projects literature. There was an additional compromising condition, which is *late changes to projects by new stakeholders*. The identification of this additional comprising condition is important, as it appears to be peculiar to the coal mining industry due to the project investment governance model and operating mine environment.

Study 1 concludes by proposing the development of 'Value Impact Assessment' processes to assess the impact of late changes on projects. The purpose of this assessment is to establish the positive or negative impact of the late change, so all stakeholders and end users are aware of the late change implications on both exchange-value and use-value. This will provide an understanding of the bearing of late decisions and a transparency of how these changes impact on exchange and use-value. The terms exchange-value is defined as the monetary amount realized at a certain point in time, whereas use-value refers to the specific qualities of the product perceived by customers in relation to their needs – or functionality.

Study 2 applied a Husserlian lens to the analysis and coding of the interview transcripts and documentation to explore if there is privileging of either exchange-value or use-value. The documentation consisted of a sample of project requirements documentation that is used to

articulate the business objective of the investment opportunity. The results revealed that requirements management documentation fails to adequately capture the use-value and benefit of the project and there is a strong privileging of exchange-value. However, in the interviews, there was only a small differential between use-value and exchange-value. The significance of this finding is that it reveals the tussle between the formal (documentation) and informal (voiced) worlds of the project teams in relation to the articulation and view of value.

1.2 Research Problem

A review of the existing literature identified that cost and schedule overruns are a regular occurrence in mining projects (EY 2015; Hart et al. 2013; KPMG 2015; Lwin & Lazo 2016; Singh 2010; Walker 2015). This is of concern as these delays and additional expenses have implications for organisational performance and sustainability (EY 2015; KPMG 2015). The literature provides various reasons for these overruns including resource constraints, stakeholder conflicts and regulatory issues (EY 2015). However, there appears to be no literature identifying that overruns in mining projects are related to particular aspects of requirements management.

The literature on construction industry projects identifies that a leading cause of schedule and cost overruns is a result of poor requirements management (Aasheim & Yang-Yang 2017; Dvir, Raz & Shenhar 2003; Yang, Chen & Huang 2012). Yu and Shen (2013) research on the construction industry in Hong Kong, identified various problems associated with requirements definition. These issues include the poor updating of requirements documentation resulting in inconsistent requirements, and unstructured approaches to requirements elicitation process.

There are strong overlaps between the between coal mining projects and construction projects (Lee 2012). It has been identified that 8 of the 9 types of delays experienced in mining projects are also experienced in construction projects (Lee 2012). Furthermore, construction companies service both the mining sector, suggesting similarities in construction and mining project characteristics (Bechtel 2016; TMM 2016). Walker (2015) supports these similarities in a review of the reliance on construction contractors to deliver large development and expansion projects for the mining industry. Based on the commonalities of the mining and construction projects, it would suggest that requirements management problem or limitations might be occurring in mining projects. There appears that there is no relevant literature in this area,

therefore a gap exists in the research to explore how practitioners perform requirements management for infrastructure projects in the coal mining industry, particularly in Queensland and New South Wales. Therefore, the research problem for this study is to the explore requirements management conditions and establish the subsequent contributing factors in mining infrastructure projects that persistently makes them vulnerable to costly overruns.

Study 2 was prompted by the outcomes of the coding for Study 1. Specifically, in coding Study 1, it appeared that there were inconsistencies in the participants' meaning and application of the term value. Section 2.4 introduces the concept of value as it relates to projects, programs and portfolios. In summary, extant literature finds that the application of value management is poorly implemented due to refusal to undertake key value generating activities and therefore the full potential of projects are not being realised (Deloitte 2013). Section 2.5 introduces the idea of exchange-value versus use-value, along with a phenomenological view of value. Therefore, the aim of study 2 is to disclose in the discourse of coal mining infrastructure construction projects any privileging or prioritization of exchange-value over use-value.

1.3 Research Question

Based on the gaps in the existing literature, the research questions for the two studies presented in this thesis are:

Study 1:

1. *What is the experience of requirements management in coal mining infrastructure construction projects?*
2. *Where the experience is less than optimal, what are the conditions that are compromising requirements management?*

Study 2:

3. *In coal mining infrastructure construction projects is there a privileging of either exchange-value or use-value?*

1.4 Significance of Research

This study addresses important problems in the field of mining infrastructure projects relating to the regular occurrence of project overruns caused by poor requirements management. By

completing this research, we will advance knowledge in requirements management in mining infrastructure projects by establishing the compromising conditions and the subsequent contributing factors through a Husserlian lens that persistently makes them vulnerable to project overruns. This research will provide project practitioners the understanding of the gaps in existing governance models and documentation and provide the opportunity to improve project outcomes by applying preventative interventions to reduce these gaps.

CHAPTER 2: LITERATURE REVIEW

2.1 Overview

The literature review summarizes five domains of research (refer Table 1) related to the research problem. To start, the problem of cost and schedule overruns is explored. This is followed by a summary of existing mining project management practices to build an understanding of the processes contiguous to requirements management in mining projects. Literature relating to construction project overruns is then reviewed, as this is a similar industry, and this sector has extant literature on requirements management (in the absence of specific mining management literature). Finally, literature relating to value in projects and specifically a phenomenological view of value is presented in preparation for Study 2, which was triggered by the findings of Study 1.

Table 1 - Literature Review Domains

Domain	Content	Important to this research
Cost and schedule overruns in mining projects	Review overruns in capital investment projects	Establish the occurrence of overruns in mining projects
Similarities in mining project practices and construction projects	Review to identify the similarities between mining and construction projects	Establishment that mining and construction projects are closely related and share similar issues
Requirements management	Review of requirements management in construction literature	Understand the issues and effect of requirement management on project outcomes in construction projects
Value associated with Portfolio, programs and projects	Review of value management in project management literature	Understand the perspectives of value by stakeholders and practitioners as described in the project management literature
Phenomenological view of Value	Review the philosophical views on value	Understand how a phenomenological view of value can provide insights regarding requirements management

2.2 Occurrence of Cost and Schedule Overruns in Mining Projects

Cost and schedule overruns are common mining projects (EY 2015; Hart et al. 2013; KPMG 2015; Lwin & Lazo 2016; Singh 2010; Walker 2015). Research by Singh (2010) provides evidence of overruns in the coal industry in India, with over 60% of projects having a schedule overrun and over 20% having a cost overrun. KPMG (2015) reviewed 17 greenfield mining

projects in Canada and determined the average cost overrun was 95% above the original estimate. Research by Lwin and Lazo (2016) into cost overrun in the Canadian mining industry determined the average cost overrun is 37%. An EY (2015, p. 3) study "revealed that overruns to the sanctioned budget and schedule commitments are the norm with … an average budget overrun of a staggering 62% in the global mining sector." With respect to Australian mining projects, in a review into planning and design of mining sector, Walker (2013) identifies significant cost overruns and schedule delays in mining projects in Australia.

The reason for cost and schedule overruns is of concern as these delays and additional expenses have implications for organisational performance and sustainability (EY 2015; KPMG 2015) . EY (2015) draws links between project overruns and shareholder return, capital productivity, corporate performance and strategic outcomes. Lee (2012) focused on coal mining projects in South Africa and identified that delays in labor, materials, equipment, contractors, owners, team, consultants, government regulators exogenous factors and specific mining related issues are the causes of project delays. Research in the Canadian mining industry found that the key factors influencing cost overruns were project size, location, sponsors headquarters, commodity and debt to equity structure. Sponsor size and mining method were found to be less influential (Lwin & Lazo 2016). A global review finds a correlation between project management enablers such as risk management, scenario planning and contingency reviews to mitigate cost and schedule overruns in mining projects (EY 2015). Lack of experience has been identified by Accenture (2011) as a key factor leading to cost overruns in Australian mining projects. Walker (2013) suggests that the key contributors to schedule delays in Australian mining projects are availability of resources, unplanned regulatory approval requirements and poor detailed planning.

Similarities in Mining and Construction Projects Global mining project management systems typically have four phases (Bueno Da Silva, Gillespie & Buckeridge 2012) and appears to be well established with mature procedures, manuals and guidelines, and considered to be at the forefront of project management practices due to the large size of their project portfolio (Steffen, Couchman & Gillespie 2008; Wittig 2014). Figure 1 describes the 4 phases. Notwithstanding the existence of mature project management practices in mining projects empirical data related projects and project management in mining is relatively scarce. As such, there are benefits in considering overruns in construction projects and understanding the similarities shared with mining projects.

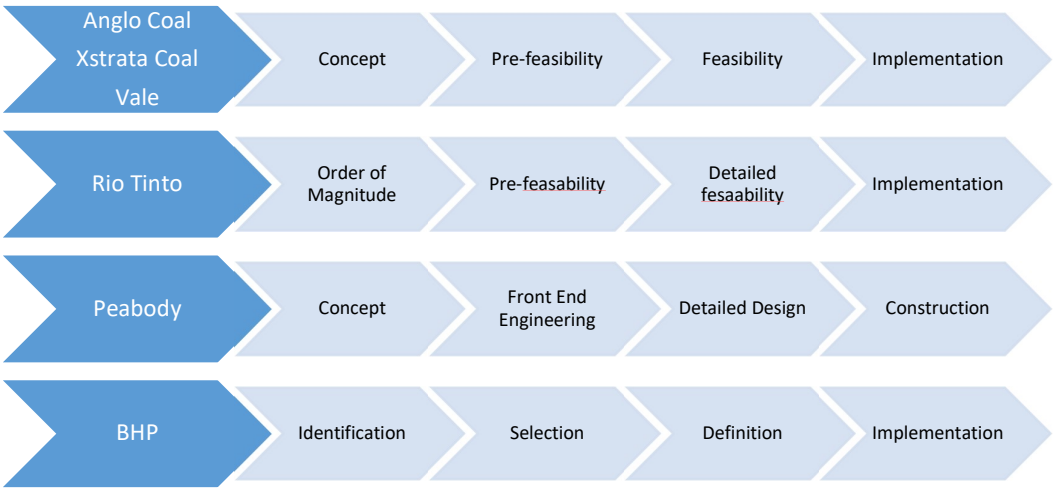

Figure 1 – Mining company project phases

Bueno Da Silva, Gillespie and Buckeridge (2012)

There are strong overlaps between coal mining projects and construction projects., for example, they share similar procurement and contractual processes and involve some form of construction (Lee 2012). Comparative research by Lee (2012) found that the 8 of the 9 types of delays experienced in mining projects are also experienced in construction projects. Often, large construction companies service both the mining sector, suggesting similarities in construction and mining project characteristics. Bechtel and the TMM Group are examples of Australian construction contractors who deliver mining projects (Bechtel 2016; TMM 2016). Walker (2015) supports these similarities between construction and mining projects in a review of the reliance on construction contractors to deliver large development and expansion projects for the mining sector.

2.3 Requirements Management

2.3.1 Requirement Management Causes in Construction Projects

Given the similarities in project characteristics between construction and mining projects, it is pertinent to consider the requirement management causes that are identified as influencing cost and schedule overruns in construction projects. Similar to the mining industry, in general cost

and schedule overruns are widespread in the construction industry, to the point where it is considered a global issue (Rosenfeld 2014).

Poor requirements management leads to cost and schedule overruns (Dvir et al. 2003; Yang et al. 2012; Aasheim & Yang-Yang 2017). Research into unsuccessful projects identified that 47% fail due to poor requirements management, with many organisations lacking maturity in this area (Smith 2014). Aasheim and Yang-Yang (2017) state that requirements management failures are the root cause of late design changes on projects and therefore overruns. Yang et al. (2012) find that when requirements definition improves, this correlates with better project outcomes. This is supported with earlier studies in the defense industry research and development projects that identified a direct relationship between extent of effort in requirements definition and project success achieved (Dvir et al. 2003).

Poor requirements documentation contributes to project overruns (Yu, Shen, et al. 2010; Lopes & Forster 2013; Shrestha et al. 2013; Karim Jallow et al. 2014; Aasheim & Yang-Yang 2017). Inadequacy of initial scoping can result in overruns (Shrestha et al. 2013). Timing of requirements documentation is linked to overruns, related to the delay in the development of various requirement documentation in respect to each other. For example, completion of the basis of design document and the stakeholder requirements Aasheim and Yang-Yang (2017). Yu, Shen, et al. (2010) find that improvements are necessary in the documentation of requirements if overruns are to be avoided. Lopes and Forster (2013, p. 142) elaborate positing problems "such as imprecise plans, loss of information and information recorded in ambiguous or incomplete form". The ongoing management of client requirement information throughout the project lifecycle in the construction industry also contributes to overruns (Karim Jallow et al. 2014).

Change requests and stakeholder management are particularly problematic in terms of requirements management. A study by KPMG (2013) of construction infrastructure projects in India revealed that 79% of respondents feel that change in project scope/design leads to project schedule overruns. A high number of change orders from the owner also increases the likelihood of overruns (Ghaleb 2013). Rosenfeld (2014) posits that multiple changes in requirements are the root cause of cost overruns. Furthermore, poor systematic processes for the stakeholder identification and therefore requirements management are linked to schedule and cost overruns (Aapaoja & Haapasalo 2014). Inability to understand stakeholders' needs is

also contributes to requirements management problems and therefore overruns (Aasheim & Yang-Yang 2017).

2.3.2 Requirement Management Practice

Requirements management practice in the construction projects has limitations and problems (Fernie, Green & Weller 2003; Karim Jallow et al. 2014; Smith 2014; Yu et al. 2010; Yu & Shen 2013). Fernie, Green and Weller (2003) describe this problem as practitioners having a lack of understanding of requirements management. Fernie, Green and Weller (2003) queried participants who were unable to provide a clear definition to describe requirements management and were also vague in their interpretation of requirements management. Karim Jallow et al. (2014) research identified the problem of complexity in the management of requirements information in client organisations, and that the construction industry underutilizes requirements management. This notion is also supported by Smith (2014), who states that only one in five organisations have high maturity in requirements management, and that half of organisations have adequate resources to undertake requirements management. The next section will review the problems associated with requirements management in construction projects.

2.3.3 Problems in Requirements Management

Several studies have explored problems associated with requirements management in construction projects, with Yu and Shen (2013) providing insight into the background of the problems in requirements management, as shown in Table 2. This review captures a wide range of requirements management problems from existing literature across several industries.

Table 2 - Requirement management issues

Source: Yu and Shen (2013)

	1	2	3	4	5	6	7	8	9
Kelly et al. (1992)	✓	✓		✓		✓			
Huovila and Seren (1998)		✓		✓					
Barrett and Stanley (1999)	✓		✓				✓	✓	
Kamara and Anumba (2000)		✓	✓		✓	✓	✓	✓	
Kelly and Duerk (20002)	✓						✓	✓	
Fernie et al. (2003)		✓	✓	✓			✓		
Kujala et al. (2005)									✓
Arayici et al. (2006)				✓					✓
Yu (2007)	✓	✓	✓		✓	✓	✓	✓	
Yu et al. (2010)	✓		✓		✓	✓		✓	

Notes: 1. Inexperienced clients in requirements management; 2. Inadequate identification and representation of requirements during the development phase; 3. Unstructured approach for requirements management; 4. Misunderstanding and misinterpretation of client needs and requirements; 5. Communication between people in requirements management; 6. Insufficient time to work out a good structure for requirements management; 7. Inadequate requirements effort throughout the lifecycle; 8. Lack of change and feedback for requirements management; 9. Lack of users participant and feeling

In terms of specific research into requirements management problems associated with the construction industry, Fernie, Green and Weller (2003); (Karim Jallow et al. 2014; Shen & Chung 2006; Yu et al. 2010; Yu & Shen 2013) have identified the issues occurring in construction projects. The next section explores these in more detail.

2.3.4 Identification of client requirements

Research by Shen and Chung (2006) determined that private industry construction projects in Hong Kong have to poorly defined client requirements briefs due to the following reasons:

- Changes in client requirements due to changes in the market or client budgets
- Requirements omitted that cause legal claims to modify the design
- Clients providing instructions to the consults to revise requirements to their specific wants due to their experience in the construction industry.

Research by Yu et al. (2010) supports poor requirements in the client briefing process and determined that in the case of experienced clients, the in-house development of briefs in an attempt to minimise the services of consultants contributed to this problem. In the case of

inexperienced clients, this problem occurred due to these clients not paying attention to the brief and relying heavily on consultants. Similarly, the misinterpretation of the client requirements, with respect to incorrect interpretation and recording of the actual client needs during the briefing phase, directly influences project success and overall client satisfaction (Yu & Shen 2013).

2.3.5 Lack of contribution from clients

The lack of active contribution by clients in the briefing process is a problem that contributes to poor requirements management in construction projects (Shen & Chung 2006; Yu et al. 2010) . This practice is due to clients not having a full appreciation of the importance of their involvements in the briefing process, reliance on consultants to interpret the needs of clients in the briefing process, and the shift of responsibility of this briefing process to consultants to enable then to remain inactive (Shen & Chung 2006).

2.3.6 Lack of impartial parties

The lack of impartiality or independence in viewpoints by stakeholders is a critical factor that contribute to requirements management problems in construction projects (Yu et al. 2010). The lack of a governance framework during the development of client requirements decisions are made on a compromised basis by impartial parties (Yu et al. 2010). Smith, Wyatt and Love (2008) identified the removal of political agenda as a success attribute in a decision-making attributes framework that contributes to success at the stage of project inception.

2.3.7 Requirements documentation, storage and distribution

The poor distribution of requirements is an issue in construction projects (Karim Jallow et al. 2014). This research by Karim Jallow et al. (2014) identifies requirements management process as sometimes being manual and paper intensive, where a large percentage of information is produced in the form of meeting minutes. The result of this 'manual' requirements management process creates a situation where different teams in a construction project work from different versions of requirements. Furthermore, this research also determined that verbal communication is regularly used to define requirements, which proved ineffective (Karim Jallow et al. 2014).

2.3.8 Requirements traceability

Research identified that there are poor systems used for traceability or dependency checking in construction projects (Karim Jallow et al. 2014; Yu & Shen 2013). Due to the lack of traceability, original requirements can be unrecorded (lost), which makes it difficult to trace backwards to determine the rationale for the selection of a technical solution or decision (Yu & Shen 2013). Karim Jallow et al. (2014) identified that there are poor processes in dependency checking between requirements. This research observed dependency and traceability checking completed by a manual process, and the success relied on the skills and experience of the practitioner to ensure no requirements are overlooked. Furthermore, Karim Jallow et al. (2014) identified there was no mapping of the requirements between project development phases, which makes it difficult to perform dependency checking and traceability. Any dependency checking was completed ad-hoc with frequent errors due the manual process.

2.3.9 Requirements change process management

Regardless of the different project management processes employed, change management processes adversely impacts requirements management in construction projects (Karim Jallow et al. 2014). The high number of changes that occur in construction projects and the manual process that is used to process requirement changes is particularly problematic (Karim Jallow et al. 2014). Furthermore, the rationale for changes is often poorly documented, which creates additional complexity during requirement auditing (Karim Jallow et al. 2014). Yu and Shen (2013) also supports the issue of a lack of well-documented management relating to changes in client requirements, which consequentially means that ineffective requirements change management is a result of multiple people being involved in the change process, and this causes inconsistency in the management of changes.

2.3.10 Lack of a requirements management knowledge

There is a lack of understanding of requirements management in construction projects (Fernie, Green & Weller 2003; Yu & Shen 2013). This lack of knowledge and ability to manage requirements extends to contractors, clients and designers in construction projects (Yu & Shen 2013). This poor knowledge of requirements management extends to the processes and definitions involved (Fernie, Green & Weller 2003; Yu & Shen 2013).

2.3.11 Late involvement of end users

Yu and Shen (2013) established that a problem associated with requirement management in construction projects is the late involvement of end users in the developments process. One of the causes of this was lack of identification of end users at the beginning of the project or the unavailability of end users during briefing periods (Yu & Shen 2013).

2.4 Value associated with Portfolio, programs and projects

2.4.1 Value Management

Value management is the strategic process implemented to harness the value opportunity and should examine all options of the project, which include the social, political, economic and environmental impacts and develop benchmarks for future decisions making with the benefits of the project associated with the performance of an organisation (Chih & Zwikael 2015). According to Standards Australia (2007), Value management is defined as "a structured and analytical process which follows a prescribed Work Plan to achieve the best value for money".

According to Hayles, Graham and Fong (2010, p. 45) value is defined as 'the relationship between cost and performance: a measure what is achieved for a given level of effort' and is represented by the following relationship:

Value ~ Functional performance / Cost of resources (Hayles, Graham & Fong 2010)

In a market review, Deloitte (2013, p. 22) stated that "mining companies fail to capture the full value potential that a mining project can offer, either due to the fact that they don't know what that full potential is (lack of knowledge/expertise) or because they refuse to undertake activities, no matter how value-accretive they are, that deviate from their expertise (ego and pride)" and that "success is more than simply delivering a project on time and on budget". The use of value management in the early stages of the briefing process can assist in optimizing the project outcomes (Yu et al. 2005), and is an essential factor in achieving quality engineering planning (Park & Kwon 2011). However, Bowen et al. (2010) research into consulting engineers in South Africa identified that only half of the practitioners were aware or familiar of value management, with the remaining having little understanding. Furthermore, Fong

(2004) identified that there is also insufficient training material and programs in value management.

2.4.2 Defining Value

The definition of value according to Standards Australia (2007, p. 1) is "an attribute of an entity determined by the entity's perceived usefulness, benefit and importance" with the interpretation of value in management literature extending from the traditional financial perspective (Allee 2000; Ang, Killen & Sankaran 2015; Atkinson 1999; Elias 1998; Martinsuo & Killen 2014). Elias (1998) identified that there are seven different classes of value being economic, moral, aesthetic, social, political, religious and judicial values. Furthermore, stated that different users apply different meanings of value depending on their perspective, and regularly confuse value with the monetary cost (Elias 1998).

Atkinson (1999) challenged the traditional notion that project management success is based on the iron triangle of cost, quality and time, and shifted towards a square root model that considered organisation and stakeholder community 'benefits' as a measure of value. Allee (2000) extended this concept further, considering the potential to expand value with the use of intellectual capital and intangibles. Allee (2000) perspective was to redefine value at an enterprise level and extend it to intangible items and outcomes such as business relationships, human competence, internal structures, social citizenship, environmental health and corporate identity. In a sense, value is the level of importance of 'things' in the wider context of what an organization is trying to achieve. Research by Martinsuo and Killen (2014) determined that the definition of value in strategic projects is beyond financial outcomes, and should consider the impact of ecological, social, health and safety, societal influence, learning and knowledge development in project portfolios. In this research, Martinsuo and Killen (2014) reviewed the variyng intrepretions of value from previous literature, as shown in **Error! Reference source not found.**, which support to varying interpretion on the defintion of value in projects. Futhermore, in the determinations of value metrics, these are derived individually due to the loose interpretation of the definition of value (Yannou & Bigand 2004).

Table 3 – Examples of dimension of value

Source: Martinsuo and Killen (2014)

Authors	Methodology and Context	Dimensions of Value	Findings for This Study
Abidin and Pasquire, 2007	Qualitative; eleven interviews: construction projects in the United Kingdom.	Economic benefit, environmental protection, social well-being.	Need for understanding the value drivers of stakeholders, in deciding about sustainability value. Need to include sustainability as part of projects' value management. Process for value management at the project level.
Atkinson, 1999	Conceptual study from IT/IS perspective.	The iron triangle (time, cost, quality, or scope), the information system (reliability, quality, use), benefit to the organization (improved efficiency, profits, organizational learning, reduce waste), and benefits to stakeholders (social and environmental impacts, user satisfaction and learning, community benefits).	Proposes that the iron triangle measures, while relevant, miss many opportunities and do not reflect project value sufficiently. Promotes involvement of stakeholders and team members with adequate authority and responsibility in the development of value criteria.
Edum-Fotwe and Price, 2009	Qualitative; Delphi workshops in a small team and modelling; construction projects in the United Kingdom.	Sustainable development: economic, social, environmental.	Mapping of categories relevant in assessing social sustainability.
Eskerod and Huemann, 2013	Conceptual study, based on standards and other literature.	Sustainable development: economic, social, environmental; short-term, medium-term, long-term.	Stakeholder issues are treated superficially in project management standards, including sustainability. Sustainable development is not, yet, explicitly covered in project management standards, but it does place new demands on project-based management.
Eweje et al., 2012	Quantitative; survey with 69 respondents, oil and gas industry, geographically spread broadly.	Strategic value: influence in the society; health, safety, security and environmental responsibility; economic profitability; stakeholder admiration.	Information feed (particularly external) during project execution contributes significantly to strategic value. Risk management better positions the manager to make value creating decisions. Managers may easily prioritize efficiency over other values, such as health and environmental issues.
Klakegg et al., 2009; Klakegg, 2010	Qualitative and quantitative—79 surveys on project governance, interviews, and 4 cases.	Public and non-profit project governance explored on many dimensions (social, strategic, sustainability, legislation, ethics), but without detail of specific indicators for \ value measurement.	Highlights that there are projects where the main purpose is for environmental benefit, to meet social needs, or to improve sustainability, and financial indicators are often not relevant. In such environments value must be measured in other ways: funding bodies require accountability and transparent reporting to demonstrate the value achieved from each dollar of investment from limited resources.

Luchs et al., 2012	Quantitative; student sample of 119 and a U.S. sample of 308 respondents; online survey with decision scenarios in consumer businesses.	Sustainable as socially and environmentally responsible (vs. functional performance).	Consumers tend to prioritize the functional performance of the product over sustainable, but such priorities depend on the consumers' values as well as the product aesthetics.
Martinsuo et al., 2013	Quantitative; survey with 126 respondents in R&D organizations in Finland.	Managers' perceptions of product development projects' organizational impacts, in terms of financial, market, technology value.	Managers prioritize financial value over market and technology value. Managers' assessment of the projects' organizational impact decreases during the project.
Martinsuo and Poskela, 2011	Quantitative; survey with 107 respondents in R&D portfolios in Finland.	Competitive potential and future business potential as measures of strategic opportunity (new product development front end success).	The use of different criteria is differently associated with the two measures of strategic opportunity pursued in the front end of new product development. Assessment formality is not significant in the model.

There are two fundamental positions on the interpretation of value (Ang, Killen & Sankaran 2015; Thiry 2004; Zhai, Xin & Cheng 2009) that are described as tangible and intangible. Tangible has a financial focus, whereas intangible contains non-commercial values. Figure 2 show a value 'see-saw' that identifies these financial and non-financial values (Ang, Killen & Sankaran 2015). Thiry (2004) identifies and describes these two categories as direct and indirect values. The direct values relate to financial impacts, whereas indirect values as similar to intangible value.

In terms of value management, there is poor understanding of this concept in the Malaysian and Ghana construction industry (Kissi, Boateng & Adjei-Kumi 2015; Lop et al. 2014). Value management in the Ghana construction industry is of low maturity with 90% of companies do not perform value management studies. (Kissi, Boateng & Adjei-Kumi 2015). Research by Lop et al. (2014) indicated that many practitioners have limited knowledge, and there is poor implementation of value management in the Malaysian construction industry. The recognition at the implementation phase of value management is also supported by research by Male et al. (2007) who identified this as the key are where value management falls down.

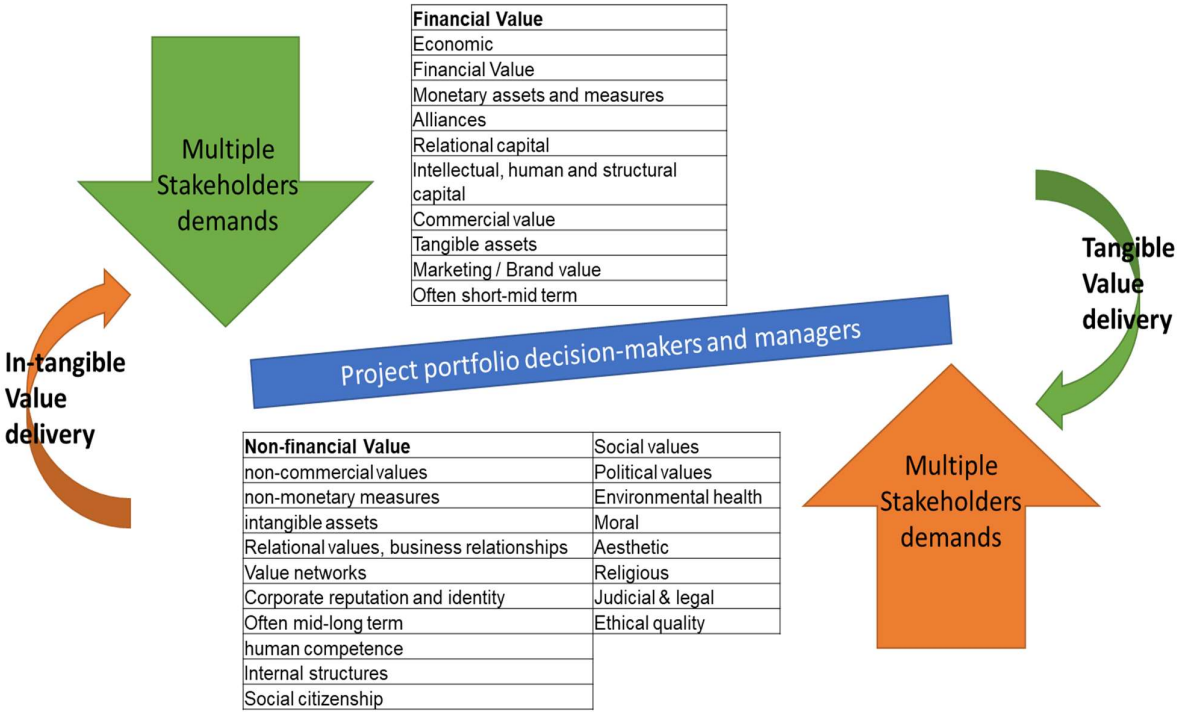

Figure 2 - Decision "see-saw"

Source: Ang, Killen and Sankaran (2015).

With respect to the mining sector, there is research into mining projects and operations that refers to value being of financial impact (Shafiee, Topal & Nehring 2009). Shafiee, Topal and Nehring (2009) provide a new financial model approach to maximise the investment decisions through optimising production rates and estimating. Similarly, Cardin, de Neufville and Kazakidis (2008) applies value improvement as an approach in order to maximise the mining appraisal project outcomes.

2.4.3 Stakeholder perspective of value

Stakeholder value is defined as '*the subjective judgment of a stakeholder, occurring at the individual level, of the total monetary and non-monetary utility experienced as a result of some decision or action by an organization'* (Lankoski 2016, p. 233). Lu and El-Gohary (2016) establish that stakeholders consider a wide range of values and that these are all moderately important to them and these values are ranked in order of priority (Lu & El-Gohary 2016; Vuorinen & Martinsuo 2019). Furthermore, stakeholders demonstrate the application of tangible and intangible value to construction projects (Ang & Killen 2016). This application captures processes that include thinking, questioning, articulating and negotiating these

tangible and intangible values (Ang & Killen 2016). Based on these finding, Ang and Killen (2016) developed 7 different value perspectives, as follows:

1. Singular (Transactional) value
2. Generative value
3. Transformational value
4. A Value Spectrum (Range)
5. Retrospective-Reflective-Future Orientated value
6. Value Networks and Relationships
7. Preventative value

Table 4 shows the characteristics and examples of these 7 value perspectives.

Table 4 – Seven Value perspectives and examples

Source: Ang and Killen (2016)

VALUE PERSPECTIVES	**Characteristics of the perspective for value identification**	**Example of value identified through this perspective**
SINGULAR/ TRANSACTIONAL VALUE	Relationship drawn between labour (provider) and output (recipient) (Smith, 1776). Routine activities, simple, found mainly in task-orientated activities, or operational supervision. Value or deliverables derived are usually planned (deliberate), expected and articulated upfront.	Transactional deliverable of operational tasks, e.g. delivering a report, delivering a new IT automated database system, contracted project deliverables
GENERATIVE VALUE	Value that is generated through projects and activities is not static but flows on (ripple effect) to deliver value in other areas, in the present and future – to benefit different stakeholders. Value derived could be planned (deliberate) or unplanned (emergent).	Value is generated in the longer time horizon, and generative value emerges as work unfolds. Aggregated project deliverables generate value for other business units; involvement in rare medical cases generate opportunities for innovation value in the medical field.

VALUE PERSPECTIVES	Characteristics of the perspective for value identification	Example of value identified through this perspective
VALUE SPECTRUMS	Value as a spectrum runs along a range, for example: Tangibility: unarticulated (qualitative) intangible and unmeasurable versus clearly articulated, defined and measured (quantitative) (Ang et al., 2015) Time-based: Short-long term Cognition: Emotional-Rational Viewpoints: Individual (micro) - Multiperspectival (macro) Function: Operational Strategic	In making sense (exploring, identifying, clarifying, confirming) of key stakeholders' expectations early in the planning phases of a business case; development and translation of strategic goals into Key Result Areas (KRAs - qualitative) and Key Performance Indicators (KPIs – measurable quantitative)
TRANSFOR-MATIONAL	Ability to change circumstances, magnitude, or quality of project, portfolio, or organisation. Adds value through reputation, publicity, morale, and reinforcing the strategic purpose of the portfolio. Likely to have a longer-term time horizon. Includes facilitating changes to stakeholder mental models or the way project management is practiced in the system.	Medical interventions transforming patient and community's wellbeing; IT and infrastructure systems transforming organizational practices and quality of service; projects as enablers of transformation in the organization
RETROSPECTIVE -REFLECTIVE FUTURE	Involves rolling hindsight in sensemaking (Weick 1995). Value is not static, it shifts (Grönroos & Voima 2012) based on past experiences, present realisations and future anticipations. Value realized in the past may pave the way for present and future opportunities.	May assist managers with identifying the 'tipping points' of knowing that the projects may have had little/some value at the start but that the overall value in hindsight can be greater.
VALUE NETWORKS, RELATIONSHIPS	Includes relationships that are collaborative or cooperative (Agarwal & Selen 2009). Describes the ability of stakeholders to\ engage and add value through their own experiences and connections with others. The strength of the relationships can determine the magnitude of the value contribution towards the portfolio.	Joint-ventures and partnerships can contribute to enhancing project capabilities, joint fund raisers Referrals for knowledge networks and network supports could accelerate or enable further efficiencies in a chain of events
PREVENTATIVE	Used in decision making under conditions of risk and uncertainty where project investments are about prevention or minimizing negative consequences to the portfolio or organisation. Business case is built around the endpoints to risk reduction, demonstrates the downside of not investing where the resulting outcomes could be major and sufficiently devastating as opposed to the often invisible upside (normality, maintaining the status-quo of the investments).	Generating information and interventions that reduce performance risk, avoid harm. Preventive projects that manage risks, for example mishap prevention, avoidance of 'imploding' occurrences (catastrophic events) that incur high costs to the organization and its community. Risk reduction of medical disasters

Furthermore, the value spectrum perspective provides evidence of practitioners alternating from tangible to intangible value perspectives. Figure 3 illustrates the value perspective.

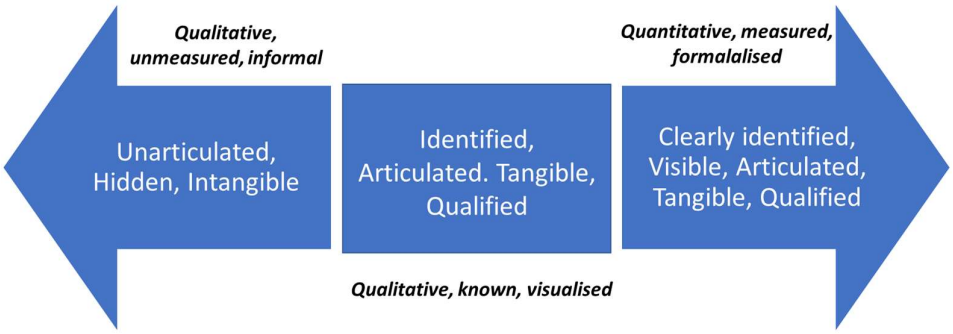

Figure 3 – Value spectrum

Source: Ang, Killen and Sankaran (2017)

2.5 Phenomenological view of value

2.5.1 A phenomenological view of value

There is an important distinction to be drawn between a phenomenological view of value and those views previously discussed. Up to now, value has been discussed in terms of an 'object' or 'relationship' that has importance, where this importance is a quality that can be externally/objectively measured i.e. cost, or be internally/subjectively measured i.e. someone feels something is important, whereas someone else does not. However, a phenomenological view considers value to be a type or form of experience we humans have, to which we attribute the term value (Farber 1964). We can liken the *form* of the experience to its configuration or the way that the experience exists or appears to us through our sensory organs and mental processes (Steeves 1997). This psychological and social view of value tries to answer the questions 'what are the necessary conditions (internally and externally of the body) for an individual to experience something they describe as valuable?

2.5.2 Phenomenological viewpoints on value

Higgins (2007) argues that from a social and psychological perspective, there are five major viewpoints on how value is derived by a person.

1. ***Value from need satisfaction:*** this relates to the feeling of value received from the usefulness of something. For example, the feeling of satisfaction obtained or the reduction in a deficiency.
2. ***Value from shared beliefs on what is desirable:*** this feeling of value is based on people having a shared sense of importance on a desired outcome. For example, the feeling we have when we share the experience of social justice, or freedom and social recognition.
3. ***Value from actual self–relation to end states:*** this feeling of value has two perspectives. The first is derived from the experience of comparing end states, where a person makes a comparison of themselves to another person with less desirable attributes, creating a positive value. Alternatively, if a comparison is made to another person with more desirable attributes, this creates a negative value. The second view comes from a shared view (with those who are important to you or you respect/admire) of a standard of excellence. As you develop toward that shared standard, you experience the other person's positive recognition of this as a value experience.
4. ***Value from evaluative inference:*** this value is derived on the use of inferences one makes from observable evidence of their own motivations. For example, an individual might observe their own behaviour in a situation and infer that either they motivated themselves to do it, or that the situation caused them to respond that way. If they concluded their motives were self-driven, then they might infer this experience to be of more value.
5. ***Value experiences:*** this viewpoint of value is the most interesting perspective with regards to this study, as it relates to experiences that are considered valuable in terms of movement or action. In a sense, value as an experience requires movement/action. To make a distinction, the other four viewpoints could be considered to be concerned with cognition, where one evaluates or forms an idea in the mind about the amount of value attributed to the experiences. However, this viewpoint considers that it is the emotional body (literally the motioned body) that creates the conditions for value to be experienced. This is explained further in section 2.5.3.

2.5.3 Value experiences

Value experiences have been classified into 5 difference areas (Higgins 2007) and are described as follows:

1. ***Hedonic Pleasure/Pain Experiences:*** this value experience is based on a person's motivation (largely unconscious or automatic appraisals) to move toward pleasure and move to avoid pain. The determination of this value generally occurs based on a retrospective basis.
2. ***Moral or Ethical Experiences:*** this value experience is based on moral and ethical actions a person is involved with and their emotional feelings generated by these actions. Unlike hedonic experience of pleasure or pain this value experience is based on a feeling of approval and disapproval.
3. ***Regulatory Fit Experiences:*** this value experience is based on regulatory fit theory, where an experience is felt that the course of action towards a goal was 'right' or 'wrong'. Value is therefore derived from the experience of pursuing a goal, rather than attaining it.
4. ***Understanding Experiences:*** this value experience emerges from a feeling of 'understanding' a person has, when they have resolved an experience they had that they were doubtful or uncertainty about. It is also an experience that emerges from our natural curiosity or interest to understand a situation that is unknown.
5. ***Agentic Experiences:*** there are two (2) forms or stages of agentic experiences. The first stage related to the feelings a person experiences from knowing they are the agent of something that has occurred, as opposed to someone else being the agent. The second stage relates to the feelings a person experiences when they know that it is their resources and their skills or mastery that has caused something to occur.

In summary, this phenomenological view of value accommodates both our genetic make-up, and how our lived experiences of the world conditions our preferences. For example, our occupation in society, as how a manager experiences value is not the same as an engineer.

2.5.4 Management values are unlike engineering values

The term 'occupation' refers to more than a job where one performs an activity. The concept of occupation arises from our innate urge to explore and master our environment (Kielhofner & Burke 1980). It is a way of describing a person's pattern of life and how they occupy their time in a role that serve society, and it can be observed in terms of a person's everyday recurrent or habitual patterns of behaviour and routines (Kielhofner 2002). Our roles and routine behaviours have a necessary order and character to them that make how we occupy our time familiar to us, and this provides us with a sense of who we are through what we do, as our occupation shapes our identity and our values. The habituation of our occupation is laden with values (Duncan 2011). Over time, by practice and the development of skills and abilities that have a purpose (regulatory fit and agentic experiences) and bring meaning (understanding

experiences) to our work. Therefore, our occupation shapes our feelings of what is *worth* doing (hedonic experiences), how we *should* behave (moral experiences), and what is *the right way* (ethical experiences) to do things. In this way, the essential practices and therefore value experiences of one occupation are not necessarily the same as the value experiences of another. Whereas a nurse feels value in caregiving (Weis & Schank 2000), so compliance with the law is a value experience for a police officer (Glomseth, Gottschalk & Hole 2011), yet a manager feel values through experiencing cost efficiencies (Petrick & Scherer 2003).

Occupational values along with institutional norms and regional culture combine to provide an individual with a sense of identity and authenticity from their work. As we identify with our role in society as either a miner, an engineer or a manager, we necessarily embrace their occupational values. However, in the workplace, not all occupational values, like all occupations, are equal. While investigating the relationship between the senior management of a hospital and the hospital's performance, Davies et al. (2007) developed a competing values framework model for organisational culture. The values of a hospital's senior management team are not necessarily aligned with the values of the dominant hospital workforce of the nursing profession. When Altun (2002) investigated the link between professional core values of nurses and their degree of burnout, they found that the indignity and depersonalisation of patients, and their lack of freedom to make recommendations concerning patient needs, were significant factors leading to occupational stress and burnout in these nurses. Law enforcement is also a field with common professional values that has seen conflict with management values (Shernock 1992). Because of their 'police' occupational values, police officers in their new management role, found decisions relating to subordinate ranks, salary, and employment, more stressful to make than tactical decisions in emergencies.

2.5.5 Exchange-Value vs Use-Value Definition

Exchange-value, is defined as either the monetary amount realized at a certain point in time, when the exchange of the new task, good, service, or product takes place, or the amount paid by the user to the seller for the use-value of the focal task, job, product, or service (Lepak, Smith & Taylor 2007, pp. 181-2).

Use-value refers to the specific qualities of the product perceived by customers in relation to their needs (Bowman & Ambrosini 2000, pp. 2-4); e.g. the acceleration and styling of a car, the taste and texture of an apple, etc. So, judgements about use-value are subjective, as they pertain to the individual consumer. In other words, the customer experiences use-value.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Philosophical stance

This study takes a philosophical position consistent with the phenomenological tradition based on Husserl (see section 2.5).

3.2 Study Design

This thesis comprises of two related studies. The first study explores issues relating to requirements management in coal mining infrastructure construction projects. The second study is an outcome of the findings of the first study, and explores the inconsistencies in the meaning and application of the term value in coal mining infrastructure construction projects. Both studies draw on a series of semi-structured interviews. The second study complements this interview data with analysis of a sample of requirements management documentation. Both studies use thematic analysis to explore the data. The first study adopts an inductive approach, whereas the second study adopts a deductive approach. Sections 3.5 and 3.6 discuss the specifics of the data collection and analysis methods for each study.

3.3 Ethics

Approval for these studies was received from the University of Southern Queensland (USQ) Human Ethics Committee prior to the commencement of data collection (Approval Number: H17REA056). All participants were informed about the nature of the research and signed consent forms prior to the commencement of interviews.

3.4 Participant selection

An experienced set of participants (n=8) were recruited through the researcher's professional network to participate in the semi-structured interviews. The number of years mining construction experience of the interviewees varied from 12 to over 20 years, and collectively they had experience across all the project lifecycle phases, from the initial identification to the execution and handover to operations. To provide a wide scope of input to this research, the roles of the participants covered a wide spectrum of mining project team roles, and included owners team management, study management, design, construction management, and project

governance and reviews. Furthermore, each the participants have relevant previous work experience in a diverse range of organisations in mining construction projects. All participant data is contained on a password protected computer.

Table 5 presents a summary of information on the research participants.

Table 5 - Research Participant Experience

Alias	Current Role	Years of Experience in Coal Mining	Current Organisation Type	Areas of Work Experience in Coal Mining
Name1	Principal Civil Engineer - Governance	13	Mining Company	• Multiple Mining Owner team companies • Design consultancy company
Name2	Coal Project Study Manager	12	Mining Company	• Mining Owner team company • Multiple design consultancy companies
Name3	Company Director	13	Design and Construction consultant and contactor to Mining Industry	• Multiple design consultancy companies • Construction Management as delivery contractor
Name4	Senior Management	18	Mining Company	• Mining Owner team company • Multiple design consultancy companies
Name5	Senior Engineer - Governance	20	Mining Company	• Multiple Mining Owner team companies
Name6	Project Services Manager	6	Mining Company	• Mining Owner team company
Name7	Senior Project Control Engineer	10	Mining Company	• Mining Owner team company • Multiple design consultancy companies
Name8	Senior Engineer	7	Design Consultant to Mining Industry	• Multiple design consultancy companies

3.5 Study 1

3.5.1 Data collection: Interviews

This research used semi-structured interviews with 8 project professionals (refer Sec. 3.4) similar to research by Fernie, Green and Weller (2003); Karim Jallow et al. (2014); Shen and Chung (2006); Yu et al. (2010); Yu and Shen (2013), who also applied interviews to explore problem in requirements management. Whilst not a large sample size, this was considered sufficient due to the research into requirement management outcomes by Yu, Shen and Chan (2010), who has a sample size of 10 and Fernie, Green and Weller (2003) who had a sample size of 12. All of the interviews were conducted individually in an office-based environment, and digitally recorded and transcribed into Nvivo for analysis. The participants have been given individual designators to protect their privacy (Name1-Name8).

The interviews followed this predetermined standard set of questions:

1. Background and experience of participant?
2. How are the anticipated project value and benefits 'requirements' defined in Australian coal-mining infrastructure projects?
3. How are the anticipated project value and benefits 'requirements' managed in Australian coal-mining infrastructure projects?
4. How is achievement of project value and benefits evaluated, measured and confirmed, or disconfirmed, following completion of the project?

Questions two to four also address the following sub question to explore the items discussed in more detail:

a. Processes / Guidelines / Procedures?
b. Systems & tools (software)?
c. What are the regular issues encountered?
d. What are the gaps/opportunities for improvement?

These questions were selected to enable a broad discussion on each of the lifecycle components of requirements management is a coal mining infrastructure construction project. By exploring each lifecycle component further, these questions generated detailed discussion and an understanding of the people, process and systems.

When discussing these various lifecycle areas of requirement management, the research participants were prompted to describe their experiences with examples are situations where the particular feeling and experience had occurred.

3.5.2 Data analysis: Inductive Thematic analysis

Inductive thematic analysis, as described by Braun and Clarke (2006), was used to analyse the interview transcripts. Thematic analysis is a flexible method for exploring a dataset with an inductive approach that 'gives voice' to the participants' requirements management experience in the coal-mining sector. Through coding the interview transcripts, it is possible to identify patterns in terms of views, behaviors and practices of the participant lived experience (Clarke & Braun 2017). Given the inductive nature of the thematic analysis, the transcripts were coded without use of any preexisting taxonomies (Braun & Clarke 2006).

In following the six phases of thematic analysis by Braun and Clarke (2006),

1. Review and become familiar with the transcribed interviews
2. Identify the interesting and meaningful data without any pre-existing code frames by the process of generating initial codes in NVivo
3. Search for themes by collating the initial codes into potential themes
4. Review the potential themes and check them against the previously coded extract.
5. Provide additional analysis and determined 6 themes that were renamed as comprising conditions.
6. Review of existing contiguous literature against the compromising conditions that were identified with the intent to identify areas of similarity and divergence with existing literature.

The approached selected for this research was to enable the key theme to emerge from the transcripts without any predetermination and is similar to research by Goel, Ganesh and Kaur (2020); Karim Jallow et al. (2014); McLeod, Doolin and MacDonell (2012); Ouhbi et al. (2015); (Goel, Ganesh & Kaur 2020); Watz and Hallstedt (2020) into project and requirements management have applied thematic analysis as the design methodology.

3.6 Study 2

3.6.1 Data collection: Interviews

Sec. 3.5.1 outlines the data collection process for the interviews.

3.6.2 Data collection: Document analysis

For study 2, 12 Statement of Requirements (SoR) documents from different coal mining construction projects were analyzed. The projects selected are from eight different mine sites, but all from a single mining organisation. This single mining organisation is a well-established large multi-national mining organisation and operates assets across multiple commodities.

The objective of a SoR document is to articulate the business objective of the investment opportunity. This document typically includes the business objectives, identifies the internal and external stakeholders, captures the stakeholder requirements, and includes an approval section for sign-off by the relevant authority. The SoR document is the primary input to other project documentation. The intent of the SoR is to describe the outcome not the solution, and to provide the opportunity for divergent thinking when identifying the project solution. Typically, the SoR is reviewed and updated at the start of each project development phase. Appendix 2 provides an example of a project requirements statement.

3.6.3 Data analysis: Deductive thematic analysis (a Husserlian lens)

The data analysis for study 2 is deductive thematic analysis with a Husserlian lens. The purpose of the applying a Husserlian lens is to explore a person's experience of an event, object or process to order to form an understanding of the structure (Creely 2018). The Husserlian lens applies 3 key processes to explore these experiences by a person, they are (1) formation of sense, (2) fixation of sense, and (3) sedimentation of sense (Chernavin 2016). This approach is applied to both the interview transcripts and the text of the SoR documentation.

In the deductive methodology, the approach of the analysis is driven by the researcher targeting a particular analytic interest in the coding phase (Braun & Clarke 2006).

The six phases of thematic analysis by Braun and Clarke (2006) were followed;

1. Review and become familiar with the transcribed interviews

2. Undertake a specifically targeted coding search for the term value across both data sets by the process of generating initial codes in NVivo
3. Reviewing these codes and identifying potential value themes
4. Review the potential value themes and check them against the previously coded extract.
5. Additional analysis to review the specifics of each theme and determined four value themes across the two data sets and then naming these themes.
6. Consisted of analysis and reporting. The analysis consisted of a review and a quantitative count on the number of occasions each value theme type was applied in the respective data set. The reporting comprised of two summary table comparing the number of counts applied for each value theme.

The deductive analysis research methodology for Study 2 was selected to enable a targeted analytic analysis subject area and in similar to recent research by Brink (2017); Joslin and Müller (2016) who applied a deductive methodology their project management research.

CHAPTER 4: RESEARCH FINDINGS

4.1 Study 1 Findings

The findings from Study 1 are summarized as follows:

- 6 conditions compromise requirements management in coal mining infrastructure projects.
- 5 of these compromising conditions are already discussed in extant construction management literature.
- 1 is new, called 'Late changes by new stakeholders'.
- Participants infer different meanings by their different uses of the term value.

The following sections with describe these findings in detail.

4.1.1 Conditions compromising coal mining infrastructure projects

Study 1 data analysis resulted in the identification 6 conditions that compromise requirements management in coal mining infrastructure projects. These comprising conditions are:

- Use of multiple, disconnected documents related to requirements.
- Lack of engagement with relevant subject matter experts.
- Solution bias during requirements specification.
- Lack of skill by those eliciting requirements.
- Lack of requirement management tools.
- Late changes by new stakeholders *(new finding).*

4.1.2 Use of multiple, disconnected documents related to requirements

The research participants discussed the multiple types of requirements documentation used in the Australian coal mining industry. These includes high-level and low-level requirements documentation. The high-level documents are commonly called "Project Requirement Statements", which outline the project requirements that align with high-level business strategy requirements. The low-level requirements documentation typically are documents called User Requirements, Functional Requirements and Technical Requirements. When discussing the various types of requirement documentation, the research participants were prompted to describe their experiences with the alignment between the multiple requirements documents.

7 of 8 research participants indicated that they regularly witness a disconnect between the multiple requirement documents. One reason that was suggested for this disconnect was the understanding in the difference between business and operation strategy:

"…you might have functional requirements from the operator which don't marry up to the business requirements. There's a conflict there…" (Name4)

"…There is disconnect between business objectives and a project objective, and a disconnect between project objective and engineering objectives…" (Name2)

A second reason suggested for the misalignment of requirements documentation was the misunderstanding between the purpose of the different type of requirements documentation when these are been developed:

"…people often confuse User Requirements with integrated Basis of Design…" (Name6)

In addition, both research participants from consulting firms highlighted that when asked if they receive project requirements statement when they are developing lower-level project requirements stated the following:

"…Very rarely. Generally, as designers we do up a basis of design..." (Name3)

**12"…our organised clients yes.."* (Name8)

4.1.3 Lack of engagement with relevant subject matter experts

Participants were questioned about the level of engagement they have experienced from key stakeholders and subject matter experts during the development phase of project requirements.

This research identified that three participants had experienced a lack of engagement with relevant subject matter experts and stakeholder. These participants reported that the level of stakeholder engagement was inconsistent and is heavily reliant to the experience and ability of the study team to engage stakeholders throughout the project lifecycle and stated the following:

"…when it gets to the end, we very often have issues within handover back to operation, which is indicative of we haven't taken operations along for the ride…" (Name4)

"…a rigid process which is supposed to get that engagement from everyone, but it often doesn't happen and it depends on how good the project manager is to enforce that or get that buy-in and engagement from people…" (Name8)

In contrast, one research participant suggested that the level of stakeholder engagement increases significantly when the project moves into execution phase and it is viewed by stakeholders and being a tangible project and stated the following:

"…into execution there's budgets being - contractors being engaged, things are happening, that's when you get a lot more buy-in…"

(Name8)

Another participant identified that the inconsistency in the level of stakeholder engagement was correlated to the size of the project in terms of its overall capital cost. It was suggested that smaller capital expenditure projects gain a higher level of input from site stakeholders due to the closer connection with site operations whereas large capital expenditure project appear too disconnected from operations and stated the following:

"…Smaller projects are better engaged with the sites and you get better feedback and better feel on the User Requirements where those larger projects don't have as good a connection back in the operations…" (Name2)

4.1.4 Lack of skill by those eliciting requirements

Analysis of the transcripts into experiences in the application of the process development of requirements documentation throughout the project lifecycle determined a lack of skills in this area by practitioners. The purpose of these questions in this area was to gain an understanding on how the requirement documentation processes are undertaken, the quality of the application, the understanding and the intent of the requirements documentation and extent of process that exist to provide the practitioner guidance. Most of the research participants advised that they have experienced poor elicitation of requirements by practitioners.

For example, participants reported that in their experience they have observed poor requirements management elicitation approaches with a lack of approval and sign off of requirements documentation as stated below:

"…I've seen SORs that weren't signed by anyone and that creates the problem we have…" (Name4)

"…I've seen examples where statement of requirements is set up at the beginning of a project, its signed off. The project team would carry on and develop the project, things would change. But they would never cycle back to the original authority and get that revalidated…" (Name5)

Another participant indicated that interpretation of the purpose of requirements documents varies between stakeholders:

"…some people's attitude in the business is a Statement of Requirements is a Statement of Requirements. It is unchanged from the start of the project to the end…" (Name2)

"…Then there is others that the Statement of Requirements is a loose, floppy document, you can change it on a whim, that's the other end. It needs to be somewhere in between…" (Name2)

Furthermore, lack of maturity in the use of requirements management tools and processes was indicated to be problematic:

"…I don't think it's that well understood. I think it's understood by a few key people here and there…" (Name1)

"…its not that we don't have the processes and the tools and all that, so that's all in place and is well ingrained, it's the application..." (Name4)

4.1.5 Solution bias during requirements specification

Analysis of the transcripts into the process and the activities implemented during the development of a project solution with key stakeholders from the project sponsoring mine site revealed evidence of solution bias. This purpose area of the research was to explore how requirements are gather with stakeholder and the influence various stakeholder may have within the elicitation process.

Multiple participants described experiences where they had witnessed solution bias in the development of requirements. Two interviewees elaborated that this occurs when authorising stakeholders have a preconceived solution for the project:

"…because leadership and management change them and everyone thinks they've got the winning idea but they haven't got necessarily the knowledge or experience of capability to sit behind it…" (Name6)

"…In this particular example, the guy just decided that it has to change. The whole project got turned on its head because of his personal preference…." (Name1)

"...There are still plenty of examples of things getting designed on the whim of a mine manager or an engineering manager that's just not founded in any good decision making process.." (Name1)

Requirements management is also reported to be compromised when the technical impacts of a solution bias are not fully understood:

"…They'll have an outcome in their head they need to achieve but not really understanding the technical aspects of how we're getting there…" (Name8)

"..Sometimes we see that someone who doesn't have that experience will come in and have a huge list of requirements because they don't fully understand them all and the implications of them all.." (Name8)

"…it's a lack of either technical understanding, or sometimes it's just a - someone's opinion on site, that they insist on a certain technical solution to a problem when it's probably not the best one…" (Name1)

4.1.6 Lack of Requirement Management Tools

Analysis of the transcripts revealed lack of understanding relating to requirements management tools. The purpose of these questions in this area was to gain an understanding on the extent of requirement management tools that are available, how these tools are used and the effectiveness of these tools.

The six interviewees who currently working for a mining company concurred that no formal requirements management tools exist for the management of mining construction infrastructure projects. The participant described that the understanding of requirement management tools was poor with many project team members not being aware that such tools are available. When the research participants were queried about the use of requirements management tools are as follows:

"… No…" (Name2)

"…If there is, I'm not involved…" (Name 5)

The absence of such results in manual mapping of requirements between documents, or at best, the use of Word or excel spreadsheets. As such, the congruency of requirements across documents is heavily dependent on the skills and experience of the project study manager as stated below:

"…No. There's no - so they're very discrete documents that are not linked together. They're just artefacts. The way they are held together is effectively though the project leader or the study leader…" (Name 4)

4.1.7 Late changes by new stakeholders *(new finding)*

Analysis of the transcripts revealed that late changes by new stakeholders comprise requirement management. The introduction of new stakeholders into capital investment projects in the Australian coal mining industry is common. Half of the research participants indicated that changes to the project requirements have occurred when new stakeholder are introduced to the project:

"…There's huge issues in defining requirements because one issue would be management change their mind a lot. What they sign up to on a five-year project timeframe, even a two-year project timeframe - not just to change their mind, there's a different management in the chair…" (Name2)

"…new mine manager comes in and basically didn't agree with anything, and didn't have - we didn't have the original documentation. That job got stopped and cost us millions…" (Name5)

"...People who haven't been involved on the journey coming in and wanting to get their own take on a project and taking a bit of interaction can create a bit of churn and take extra time either to get them up to speed with where the project's at or just take a completely different direction because they changed the project requirements…" (Name8)

One research participant stated that these new stakeholders need an increased awareness of the implications of the changes that they make to project requirements as stated below:

"…Not introducing new stakeholders part way through the design process, and if one is introduced, they need to be aware of what phase the project is at, and the implications…" (Name1)

4.1.8 Comparison to Existing Literature

A comparison of the compromising conditions to existing literature finds that five of the conditions identified in Study 1 correlate with the findings of previous requirements management literature. However, the compromising condition of 'late changes by new stakeholders' appears to be a new addition (refer green row in Table 6).

Table 6 presents a review of the compromising conditions identified in this study and links them, with the exception of 'Late changes by new stakeholders', to the existing literature.

Table 6 - Existing literature comparison

Compromising Condition identified in Study 1	Description of compromising condition in existing literature	Existing Literature References
Lack of engagement with relevant subject matter experts	Identified that clients and stakeholders are not actively involved in the development of the briefing process and therefore a communication gap exists.	(Shen & Chung 2006); Yu et al. (2010); (Yu et al. 2005)
Use of multiple, disconnected documents related to requirements	Missing or inconsistent requirements occur due to poor documentation of client updates	Yu and Shen (2013)
Late changes by new stakeholders	Nil	Nil
Solution bias during requirements specification	A lack of unbiased parties in project decision making due to a lack of governance frameworks	Yu et al. (2010)
	Decision making to include the removal of any existing political agendas	
Lack of skill by those eliciting requirements	Lack of standardised approaches and systems in the requirements management process	Fernie, Green and Weller (2003); (Yu & Shen 2013)
Lack of Requirement Management Tools	A shortage of requirements management tools used in construction projects	Yu and Shen (2013)

4.1.9 Confusion regarding the meaning of value

Stage 1 data analysis also found that all eight participants used the term value in differing ways. During the interviews, a participant would refer to value regularly, however the meaning that appeared to be ascribed to value was fluid and unclear. In some instances, the interviewee would use the word value in the context of cost, and at another time it appeared to refer to a benefit. Below are coupled examples of value statements by participants that appear to indicate different meanings being applied to value:

"…$50,000,000 NPV, that's what this project's going to bring. Then 12 months after the project has been implemented, you'll do that check to see if the values have been brought in…"

"…analyse the business case and determine the value it's added to the business, but I'm not sure the value part is done well…" (Name2)

"…They do confirm the values achieved. They effectively rerun the investment evaluation model.."

"…The issue though is it seems those users work on the basis that they think they have optionality and there's value in having optionality…" (Name4)

"…How much value did we lose by that decision, oh let's just cut - they cut 15 per cent off the total project sum, but probably took away 30 per cent of the value…"

"…the value of this project is Peak Downs coal..." (Name5)

"…10 per cent increase in growth, 10 per cent reduction in cost et cetera. All of those requirements come to one group, one small group being the project squad, right? Depending on a certain value threshold…"

"…Let's talk about measuring value at the end and comparing back to what we started…"

"…determining the criteria for that validation as well. So how are we going to measure value at the end? When are we going to measure it? Are we going to measure it here, or are we going to measure here? What are the guidelines around doing that?..." (Name7)

"…All projects of this size will measure value after six months of operation of that project…"

"…it depends on what the value priority list is at the time, if it's around coal tonnes or whatever it happens to be…" (Name8)

4.2 Study 2 Findings

This section provides the findings from the analysis of the interview transcripts and Statement of Requirements document using the phenomenological lens of exchange and use-value. To summarise:

- Analysis of the interview transcripts determined that use-value was the dominant value term applied. Use-value was referred to in thirty cases followed by exchange-value with

twenty-three cases and on twelve occasions the underlying meaning of value (i.e. use of exchange) was unclear.

- Analysis of the documentation determined exchange-value was the dominant value term applied. Exchange-value was documented 55 times followed by use-value 8 times, and on 5 occasions use and exchange-value were applied together.

The following sections with describe these findings in detail.

4.2.1 Findings from deductive thematic analysis of interviews

The term value was used a total 65 time in the interviews. An exchange meaning was evident on 23 occasions, and a use-value meaning was coded 30 times. There are 12 examples where the meaning of value was unclear and ambiguous. Table 7 below provides a count of the number of references to exchange, use and unclear meaning across the interviews, with examples provided. Appendix 1 contains the table with the full quotations from the participants.

Table 7 – Value application - Interviews

Participant	Exchange-value	Use-value	Unclear
Name1	**0**	**4**	**0**
Examples		…value proposition, what's best for the business. That's right. Building a business case..	
Name2	**6**	**3**	**2**
Examples	There is a process that maps out who needs to sign and a review on approve and endorse process that's very clear, but - and that's based on capital value.	…try and analyse the business case and determine the value it's added to the business	It's hard to say the balance between no decision at all, or you can destroy value by delaying decision, but also you can destroy value by making a decision too early. There's a fine balance.
Name3	**1**	**0**	**1**
Examples	We actually look at the value proposition and put certain what we think could be possible value ads or reductions in the scope that would still keep the same level of service and provide a better, more economic outcome for the client.		It's been both ways. Some aren't so good but others create value and so it's a bit..

Name4	**6**	**11**	**0**
Examples	They do confirm the values achieved. They effectively rerun the investment evaluation model.	The issue though is it seems those users work on the basis that they think they have optionality and there's value in having optionality.	
Name5	**3**	**3**	**0**
Examples	How much value did we lose by that decision, oh let's just cut - they cut 15 per cent off the total project sum, but probably took away 30 per cent of the value.	…real value is realised in the front end of any project. If I look at my - I'm about the technical solution.	
Name6	**1**	**2**	**4**
Examples	Changes in requirements? It just means a lot of rework to be honest.	it drives you down a certain path and puts blinker on you in terms of where they're actually could be some value. So you often end up with things that are over-engineered…	If you're always focused on value, what's the best value outcome, you should be able to look at all those things and go, this is the best value, but that's not what's happened.
Name7	**3**	**6**	**5**
Examples	Those changes mean the execution takes longer to deliver. So that's another value attrition.	Value Improvement Practice, exactly. So you say okay, that option looks pretty good. Now what can we do on that, to make it better value adding.	But I think those changes, I wouldn't think they alter the value, overall value significantly.
Name8	**3**	**1**	**0**
Examples	Perceptions that project costs are high and don't add value when they don't understand the bigger picture.	Doesn't add value to the project. So the outcome of that is having the right people on the right projects.	
Total	**23**	**30**	**12**

4.2.2 Findings from deductive thematic analysis of Statement of Requirements documents

Thematic analysis of the Statement of Requirements documents found a total of 68 uses of the term value. Exchange-value was recorded on 55 occasions, with use-value only being documented on 8 occasions. There are five examples where the exchange and use meaning are combined. Table 8 provides quantification of these instances of each value per Statement of Requirements document. Examples of the different meanings are also provided.

Table 8 – Value application - Documentation

Item	Exchange-value	Use-value	Combined
Project 1	**6**	**2**	**1**
Examples	References capital cost and operating cost	Preserve the value of future sustaining and growth options	Identify, evaluate, select and implement an optimal coal haulage system considering capital cost, operating cost and mining flexibility
Project 2	**5**	**0**	**1**
Examples	References production volume and reduce operating cost		Select the highest value generating stripping method measured using NPV over the life of the investment
Project 3	**3**	**0**	**1**
Examples	References increase volume and reduce operating cost		Consider the best conveyor, surge bin, and road scope options and reducing cost though using existing infrastructure
Project 4	**4**	**1**	**1**
Examples	References cost reduction and reduce operating cost	Operation Prior to Exhaustion of Existing TSF Capacity	Ensure the value trade-off of capital expenditure profile and conduct value optimisation practices, including cost (trade-offs), technology, route, material and design optimisation
Project 5	**6**	**1**	**1**
Examples	References productivity improvement and reduce operating cost	Value Driver table global communications systems vision	Maximise value by lowering operational costs and designing a scalable solution that interfaces with the organisation
Project 6	**4**	**2**	**0**
Examples	References lower mining cost	Manage the cultural heritage values of the project	
Project 7	**4**	**1**	**0**
Examples	References capital cost and revenue	Creates value by replacing existing spirals with higher efficiency reflux classifiers	
Project 8	**6**	**0**	**0**
Examples	References capital cost and revenue		
Project 9	**4**	**0**	**0**
Examples	References capital cost and revenue		
Project 10	**5**	**0**	**0**
Examples	References operating cost and capital cost		

Item	Exchange-value	Use-value	Combined
Project 11	**3**	**1**	**0**
Examples	References operating cost	Manage the cultural heritage values of the Project	
Project 12	**5**	**0**	**0**
Examples	References capital cost and revenue		
Total	**55**	**8**	**5**

CHAPTER 5: DISCUSSION

5.1 Penny wise, pound foolish: the domination of exchange-value

The findings from Study 2 reveal that while use-value dominated the interview narratives, exchange-value is pervasive in the SoR documentation. A reason for this discrepancy is the dominant influence of management discourse. Bruce et al. (2011, p. 154) describes discourse to be the use and process of language to social, political and cultural formations, which not only reflects social order but also shapes social order, and individuals' interaction with society. In essence, discourse drives what managers do, and is an influential tool that is applied across multiple areas of management including strategic change management, strategic development processes, securing capital investments and stakeholder management (Bruce et al. 2011). Research by Davies et al. (2007) that explored the relationship between and organisations performance and the culture of the senior management and established that management discourse results in a contingent relationship between culture and performance in English hospitals. Furthermore, management discourse conditions the forms and types of metaphors management use to describe their organisations as machines, sporting teams and tribes in a framework to create organizational culture thought rituals, rites, and organisational figure heroes (Bruce et al. 2011).

In the interviews where use-value dominated, it is possible that the interview participants felt less pressured to be influenced by a management discourse. Rather, they could revert to their occupational roots in engineering and discuss their experiences in terms of the 'use' to gain from a project. To recall, engineering values are associated with accuracy, sound design, functionality, and efficiency in terms of reducing energy and waste.

The pervasiveness of exchange-value in the requirements documentation reflects the perspective of the authorizing personnel. To elaborate, generally, authorization will be by a senior manager who is well-removed from 'the tools' or has shifted into mining from a management or accounting background in a different discipline who will approve these documents. As such, they are looking for documentation that reflects the management discourse with its focus on exchange-value.

This finding suggests that management discourse is disproportionately embedded in project work documents in the mining sector. This situation is concerning, as it privileges exchange-value over use-value, and this condition may be a root-cause issue that compromises requirements management. In other words, the requirements management documentation is written for management consumption rather than project delivery (engineering) use. For example, when business case documentation requires a statement about the value and benefit of a project, there is an expectation by management that the description will capture these elements in terms of 'exchange-value' concepts such as cost-benefit ratios and rate of return. However, the clients for these projects require the projects to satisfy engineering or production needs, which is to say that the benefits come from the outcome of a project are derived from a statement of its 'use-value'. More specifically, mining engineers or engineering/mining workers consider the success of the project in terms of use-value (the ability of the outcome of a project to satisfy a need). This is in contrast to the authorizing managers who is conditioned to suppose value in terms of exchange-value, such as the price or cost of production.

Subsequently, this study proposes that a contributing factor to cost and schedule overruns in mining infrastructure projects is the differing conceptualization of value across the organizational structure of mining companies. Requirements management documents are imbued with the values of management (exchange-value) rather than the needs and values of the client (use-value). Whilst requirements management documents and processes are intended to describe, convey, and safeguard the project's use-value for the client, the consumers of these documents are largely management who are more interested in and conditioned by the concept of exchange-value. Furthermore, the requirements management documentation and processes that influence the discourse around the project focus on its exchange-values, thereby marginalizing if not excluding its use-value, which ironically in the long run, drastically increases the cost of the project.

The domination of exchange-values in mining projects are likely to influence the delivery and intension of the use-value of projects through scope reduction to achieve an exchange-value metric. Whilst this reduces the capital expenditure of the project, it might increase operational costs though the functionality of the project by the end users. This might then influence the productivity of the mine site, which results in an increased overall mine site operation cost. Alternatively, the loss of the use-value or functionality in the eyes of the end user will potentially initiate a secondary 'retrofitting' project. This may influence production, add

additional costs and duration, and raise the question of the real benefit of not including this in the original project requirements. In essence, this is similar to the older saying “penny wise, pound foolish”.

Furthermore, the outcome of the domination of exchange-value over use-value suggests that engineers are exposed to comprising conditions in the project development process. This compromising relates to the ability of those tasked with defining requirement to navigate the requirements/design process to properly capture use-value in the documentation, without the metaphorical hammer of exchange-value thumping down and removing scope as the project delivery processes unfolds.

5.2 Late changes by new stakeholders

The study 1 findings reveal that five out of the six conditions that compromise requirements management in the coal-mining sector also exist in construction management literature. This alignment can be attributed to the similarity in conditions experienced in mining and construction projects (Lee 2012). For example, the guidelines and processes applied in mining construction projects have been determined as mature and leading project management practices (Steffen, Couchman & Gillespie 2008; Wittig 2014). Furthermore, it has been established that many contractors that deliver mining projects are from the general construction industry (Lee 2012). This commonality in contractor base likely results in similar practices, both effective and ineffective when applied in both industries.

However, a new compromising condition emerged, which is *late changes by new stakeholders*. Research by Yu and Shen (2013) established the comprising condition of late involvement by end users which has some similarities around the aspect of late involvement however this condition relates to end users whereas the new condition relates to the introduction of new stakeholders. Based on the interviews, this situation often refers to the appointment of new mine site management. These changes to projects appear to be unique to the mining industry based on the capital approval framework for projects specifically below 2 million dollars. Many projects are approved and authorized by a member of the mine site management team. Based on this single person approval model, the manager will make their decision drawing on their personal experience, perception and technical bias (rather than a group decision or formal assessment process) as identified in Section 4.1.7. This condition has similarities to lack of

impartially which has been acknowledged by Smith, Wyatt and Love (2008); Yu et al. (2010) as a comprising condition however this existing research identified generic stakeholders as exhibiting impartially whereas this research has identified site management as the key stakeholder. Furthermore, as the incumbent site manager requires changes that results in the initiation of a project with certain desirable elements of its specification. However, all of these specifications can be subject to re-prosecution by the incoming Manager, who will make judgements and changes based on their own experience, which have the likleyhood of differing from the previous manager. Furthermore, the research identified that these changes occur without the technical understanding or of sound decision-making process by this manager.

Consequentially, allowing changes to be made without deference to past decisions, importantly raises the situation that late stakeholder can easily dismiss the value that was initially sought. Put simply, value is not valued. Change of direction by a new stakeholder dismisses the previous exchange and use-value and distorts the outcome through the establishment of a new project direction. Therefore, value is also not valued (thought important) though the governance framework, which is contributing to compromising requirements and value by facilitating the ease of late changes to projects by late entry stakeholder, such as new mine management. These compromising conditions are a result of a governance structure that enables single decision making that undermines the management of portfolios that contain thousands of effectible projects worth several billion dollars. It appears that the governance model separates projects into financial value (exchange-value) and provide lines of accountability to individuals at certain organizational levels to manage a capital portfolio that is based on a capped expenditure amount.

Based on late changes to projects supported by a governance model that compromises requirements and use-value, what is not clear is the differential of the use-value from the baseline case (established project direction) to the new case (new project direction). This is in contrast to identifying the differential of exchange-value, which will be the difference in the total capital expenditure for the project. The creation of a ‘Value Impact Assessment’ process to assess the impact of late changes on the project is therefore necessary, if it is assumed that structural changes to the governance framework is unlikely due the other implications. The purpose of this assessment is to establish the positive or negative impact of the late change, so that all stakeholders and end users are aware of the implications on both exchange-value and

use-value. This will provide an understanding of the bearing of late decisions and a transparency of how these changes impact on exchange and use-value.

CHAPTER 6: CONCLUSION

6.1 Summary

Study 1 set out to test the experience of requirements management in mining infrastructure projects, and if this experience is less than optimal, what are the conditions that are compromising requirements management. To understand this experience, the study explored the definition, management and realisation of requirements management throughout the project lifecycle though the lived experiences of the practitioners. This lived experience explored the processes, guidelines, procedures, systems and tools of each phase from the perspective of the mining owner teams, consultants, and contractors to gain an understanding of the application, challenges, and gaps.

The study 1 revealed that there are 6 compromising conditions that impact requirements management in coal mining infrastructure projects. These compromising conditions are:

- Use of multiple, disconnected documents related to requirements.
- Lack of engagement with relevant subject matter experts.
- Solution bias during requirements specification.
- Lack of skill by those eliciting requirements.
- Lack of requirement management tools.
- Late changes by new stakeholders *(new finding).*

This study determined that 5 of these compromising conditions are already discussed in extant construction management literature. However, a new comprising condition was exposed, called *late changes by new stakeholders*. It was considered that this new compromising condition could be peculiar to coal mining projects and not occur in the construction industry due to the capital approval framework for projects. Many projects are approved and authorized by a member of mine site management team. Based on a single person approval model, the manager will make their decision drawing on their personal experience, perception and technical bias, rather than a group decision or formal assessment process.

Furthermore, the analysis of the interviews in Study 1 revealed that participants inferred different meanings to the term value by their different uses of it. This provided a segue into Study 2, where this confusion was explored further using a phenomenological lens to

understand the potential references of the term value as either exchange-value or use-value in the interview and project requirements documentation, and to establish if there is a privileging of one over the other.

The analysis of interview transcripts determined that use-value was the dominant meaning of value. Use-value was referred to in thirty cases, followed by exchange-value with twenty-three cases, and on twelve occasions the underlying meaning of value (i.e. use of exchange) was unclear. An analysis of the documentation determined that exchange-value was the dominant meaning of value. Exchange-value was documented fifty-eight times, followed by use-value (eight times), and on five occasions use-value and exchange-value were applied together.

The preference of exchange-value was considered to result from the influence of management discourse. This discourse is clearly evident in the documentation that management has approved. However, in the interviews the participants appeared to feel less pressured to adopt a management discourse.

6.2 Contribution of Research

6.2.1 Theoretical Contribution

This research has provided the establishment of the two theoretical contributions in coal mining infrastructure projects as follows:

1. An additional compromising condition to requirements management: late changes to by new stakeholders

2. The privileging of exchange-value over use-value in requirements management documentation.

6.2.2 Practical Contribution

The practical contributions of this research based on the findings are as follows:

1. Exposure of gap in the existing governance model, which supports the existence of the additional requirements management compromising condition.

2. The opportunity to undertake a review of the existing procedures and processes to rectify the contributing factors of the additional requirements management compromising condition, by the implementation of 'Value Impact Assessment' process to assess the impact of late changes on the project.

3. The domination of exchange-values in mining projects may lower project capital costs, but with the reduction of scope this may influences the extent of use-value the project delivers, and increase operational costs though the functionality of the project by the end users.

4. The loss of the use-value or functionality in the eyes of the end user will potentially initiate a secondary 'retrofitting' project. This may influence production and add additional costs and duration.

6.3 Future Research

Future research opportunities to extend this research are as follows:

- Expanding the interviews size across a cross section of mining projects and increasing the diversity of the participants to further validate the findings of Study 1

- Expanding the document analysis of the core requirements statement document to include additional mining organisations to validate the privileging of exchange-value over use-value

- Expanding the document analysis to review addition requirements documentation types across multiple mining organisations to explore the extent of privileging of exchange-value over use-value and other potential issues

6.4 Limitations

The scope of this research is limited to the capital expenditure infrastructure projects undertaken by coal-mining companies operating in the Queensland and New South Wales. The participant for the interviews consisted of personnel form mining operations, consultants and contractors that provided services to deliver capital infrastructure projects and were selected through the researchers existing networks in the mining industry.

The documentation used for the analysis in this research is from one case mining organisation and is a single requirements documentation type. However, this requirements document type is considered the most critical and highest in the hierarchy of requirements documentation by project practitioners.

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Appendix 1 - Value Interview Quotes

Value Quotes	Interview
Interviewee: It can. It can, and it has. Sometimes it doesn't but if - there are some big egos out there, and in this particular example, the guy just decided that it has to change. The whole project got turned on its head because of his personal preference. Facilitator: So that's - yeah, so those requirements which were set and was agreed with the business is therefore now being completely changed and that value... Interviewee: Yeah.	Name1
Facilitator: Yeah, so that potentially is a gap. You're suggesting that's not a - we've got to get away from personal preferences. It's about basically a value proposition. Interviewee: Yeah, a value proposition, what's best for the business. That's right. Building a business case for a particular project.	Name1
Facilitator: Yeah. Talked about strategy areas in the business, and those sorts of I guess areas. Have you - how have you seen a general strategy being sort of handed down into I guess the projects area, to then sort of articulate what t the value is that they're going to achieve? Then defining that into sort of I guess business objectives, to then set the scene for the project? Is that something you've... Interviewee: Yeah, sort of a pre-identification phase step called opportunity assessment. It's - I think they look at all perceivable possible options to, say, increase a pit's capacity or improve the way coal is hauled around a site or whatever. They'll look at sort of concept - high level concept options, and then identify that there are a couple of options that are valid. Those will get fed to projects to study further and develop further and prove up, and - yeah, check the feasibility of, et cetera. Then to select a go forward case and build on that.	Name1
Facilitator: I guess sort of some of the key themes I'm seeing here today is that it's potentially different people with different perceptions around what is necessary to deliver the value, and that changes sometimes within the project team, project personnel changes and also stakeholder changes are probably key reasons why requirements change, and potentially value could be lost. Is that sort of a [feeling] to summarise that? Interviewee: Yeah I think so, and ensuring there's separation between what the stakeholder needs and what they actually want as well.	Name1
which then you create project objectives to achieve those business objectives, so that's the first place you start. Whether it be value, whether it be growth	Name2

There is a process that maps out who needs to sign and a review on approve and endorse process that's very clear, but - and that's based on capital value	Name2
Your whole intent is we have formalised value improvement processes to get more and more business value out of it, it's something as simple as a capital cost review to operate a cost review	Name2
project thinks is right and what an operator thinks is right is a completely different thing. So a project's got to focus on value and capital cost where in an - especially operations, it's usually operations that are driving the execution to change things	Name2
waste of money. You can see plenty of that bare bones infrastructure they could have used more capital and resulted in a better value outcome	Name2
value isn't necessarily just NPV at the end of the day, it's a mixture of things. The best value outcome in 2012 is going to be a different value outcome in 2014	Name2
$50,000,000 NPV, that's what this project's going to bring. Then 12 months after the project has been implemented you'll do that check to see if the values have been brought in. So on a - does the new conveyer give us 2,000,000 tonnes per annum? Does the new digger give us 3,000 BCM an hour, that's done quite well, those numbers, but whether the business case has been achieved and the value has been achieved	Name2
they try and analyse the business case and determine the value it's added to the business, but I'm not sure the value part is done well. The tonnes per hour…	Name2
The only way you can really assess the true value, if the true value of that project has been delivered is to assess it at year 30	Name2
It's hard to say the balance between no decision at all, or you can destroy value by delaying decision, but also you can destroy value by making a decision too early. There's a fine balance	Name2
That could be because you didn't interpret the requirements correctly and you didn't understand the value case properly and it can also be because of a change in conditions or strategy	Name2

We actually look at the value proposition and put certain what we think could be possible value ads or reductions in the scope that would still keep the same level of service and provide a better, more economic outcome for the client.	Name3
a large part of them are driven by tangible quantifiable metrics if you like, that you can value. People can get their heads around that. But in those as well there's a whole lot of intangible aspects that you can't - you can't fully value. That would be things like sustainability, we want to maintain our license to operate.	Name4
value is very much about perceptions. Depending on who you talk to on any given day, that perception may change	Name4
we want to relax one of these requirements because it's good for the project overall, but the requirements happen to be stifling or is handicapping the value add	Name4
the better decision that I make is the one that says I get more or less value for more or less cost or whatever the metric you're using	Name4
, I can give you this alternative that only meets nine of the 10 requirements, but it's by far the better value creating option. That means you're making a change back in your requirements	Name4
the outcome of obviously that is if you make a suboptimal decision, you've probably got a suboptimal project, which means you've got a suboptimal solution for the business in terms of value	Name4
some value destroying conditions within the project? Interviewee: Yep, absolutely. But it's a real - and this is more a cultural issue than operating discipline issue. So statement of requirements, I've seen examples where statement of requirements is set up at the beginning of a project, it's signed off. The project team would carry on and develop the project, things would change.	Name4
The issue though is it seems those users work on the basis that they think they have optionality and there's value in having optionality	Name4
. From the operator's side or the strategy side, they don't understand how important this is, therefore they don't value this as an initial step to set a project up for success.	Name4
It's about unlocking value. It's all built around I can give you a better outcome but I can't give you all your requirements.	Name4

This is what I can give you. Very often that conversation, so that trade off of value versus the requirement doesn't happen	Name4
the very first step where you start to optimize the value of your investments is in your requirements documents	Name4
They do confirm the values achieved. They effectively rerun the investment evaluation model	Name4
the statement of requirements was not correctly managed or used, the value, although there may be value on the project where it may not be fully optimised, there may be lost opportunity	Name4
the model may not fully actually represent the business requirements to begin with. It may be a suboptimal model. As in it provides value, but not as much value as it could have.	Name4
The important document for any phase is a Statement of Requirement. I think we really understand how important that is, because we get a stakeholder to sign off on it. It doesn't go in to the technical detail, but basically it's what's the problem, what's the solution. That's basically - obviously that idea, here's your problem, you frame up some different ideas and you value proposition them	Name5
real value is realised in the front end of any project. If I look at my - I'm about the technical solution	Name5
The whole value, the NPV was about	Name5
How much value did we lose by that decision, oh let's just cut - they cut 15 per cent off the total project sum, but probably took away 30 per cent of the value.	Name5
Even if we save 15 per cent of the capital, we stripped more of the value. If the project was going to deliver X, we actually took 20 to 30 per cent of the value out by saving half the capital	Name5
the value of this project is Peak Downs coal	Name5
if you're chasing value, in my opinion the best way to do it is that your stakeholder requirements so should be - so I've [unclear] start with stakeholder requirements, that	Name6

incorporates your key technical stakeholders as well as your key financial stakeholders, to make them as broad as possible	
What I mean by that is when people become so prescriptive in the stakeholder requirements to the point where they're almost facilitating some development in the user requirements, it drives you down a certain path and puts blinker on you in terms of where they're actually could be some value. So you often end up with things that are over-engineered,	Name6
If you're always focused on value, what's the best value outcome, you should be able to look at all those things and go, this is the best value, but that's not what's happened.	Name6
if we do it this way and we change the stakeholder requirements or we think that you're leaving this much value on by not pursuing this because you've excluded it in the stakeholder requirements	Name6
Have you seen that regularly occur where changes in requirements has then affected the value of the project? Interviewee: Changes in requirements? It just means a lot of rework to be honest.	Name6
The biggest loss of value for us through is actually in the ramp-up of a project. As we go from having completed construction into commissioning and handover to ops and reaching the full implementation	Name6
Do you think it take some requirement management tools, like software and things like that? Without going into the detail about what they do and don't do, but is that something that you feel as though there could be an opportunity there that might had some value if it's to try and close the gaps on potential manual processes to make sure that if someone leaves that that information is not lost, it is stored and… Interviewee: I do think there's value in that kind of thing.	Name6
we're two years down the track things have changed. What your project delivers now is of no value to us. That's the biggest problem	Name7
Whether it's NPV of course it could be intangible value as well.	Name7
But if your SOR process is not managed, if the expectations is not managed across as the project is changing, or the study is changing. You're basically starting to reduce the value. However in your mind your thinking you're still delivering that value.	Name7

The flaw with that model in my opinion, is that that looks only at the project as a standalone project. Yes, the project will be successful, but the business might not deliver any value.	Name7
Value Improvement Practice, exactly. So you say okay, that option looks pretty good. Now what can we do on that, to make it better value adding	Name7
So when you go from selection to definition, the IAR should state what was your original value proposition. What have you done so far, what's a value addition, or value attrition.	Name7
Those changes mean the execution takes longer to deliver. So that's another value attrition	Name7
But I think those changes, I wouldn't think they alter the value, overall value significantly.	Name7
So the question is how do then measure the value?	Name7
we're going to deal with value here by the requirement specifications and everything. By the time we get here, is anyone measuring what the value is? How do we actually then measure what the value attrition is?	Name7
Let's talk about measuring value at the end and comparing back to what we started	Name7
10 per cent increase in growth, 10 per cent reduction in cost et cetera. All of those requirements come to one group, one small group being the project squad, right? Depending on a certain value threshold	Name7
determining the criteria for that validation as well. So how are we going to measure value at the end? When are we going to measure it? Are we going to measure it here, or are we going to measure here? What are the guidelines around doing that?	Name7
All projects of this size will measure value after six months of operation of that project	Name7
Perceptions that project costs are high and don't add value when they don't understand the bigger picture	Name8
Doesn't add value to the project. So the outcome of that is having the right people on the right projects so they've got the experience and continuity to make good decisions through the management and delivery of a project	Name8

the value because it costs more and it's been taking long to do it's been less value	Name8
it depends on what the value priority list is at the time, if it's around coal tonnes or whatever it happens to be	Name8

Appendix 2 - Example Project Requirements Document

Project Manager:		**Prepared By:**	
Job Number:		**Checked By:**	
Project Purpose		**Performance Criteria**	
		Requirement	**Measure**
Project Objectives			
Key Stakeholders		**Role**	**Department**
Sign-Offs		**Stakeholder Signature**	**Stakeholder Name (Printed)**
			Date