University of Southern Queensland

Faculty of Engineering and Surveying

Creating a performance management system for contractors to assess subcontractors

A research project submitted by

Nicholas Linnan

In fulfilment of the requirements of

Bachelor of Construction (Management)

October 2015

Abstract

Research suggests that up to 90% of works within the construction industry are subcontracted. Thus, it is important to find way of measuring performance and rewarding higher performing subcontractors. The literature review has highlighted limited work within this field of subcontractor selection and evaluation within the construction industry.

Due to this, there was a need to conduct an extensive literature review to understand what is performance management within the construction industry, how can it be applied in a contractor/subcontractor relationship and what could the benefits of such a system be in order for the performance management system to have relevance within the construction industry.

There was a need to measure performance, and have Performance Management Indicators tailored to suit individual needs of an organisation. The literature review identified 51 potential Performance Management Indicators which could potentially be used to assess subcontractors. Due to this, it was necessary to develop a methodology that could be used to create and implement a functional performance management system that could be used to identify the Performance Management Indicators suitable to an organisation as well as provide a step by step process to the performance management system for ease of implementation.

In order to test this performance management system, a case study needed to be undertaken with a contractor's organisation. 13 of the contractors representatives partook in the case study and through the use of surveys and informal interviews, they selected the top 10 Performance Management Indicators, based on their experience and organisational culture of the contractor's organisation. These top 10 Performance Management Indicators were then provided to a group of 5 recently used subcontractors to check the validity of the Performance Management Indicators and to establish commonalities between the two parties.

Using these top 10 Performance Management Indicators as a means of evaluation is an organisational specific requirement. However, the literature

review suggests that there is a way that this information can be used to determine future performance of the subcontractor based on past performance. Chengs (2014) RPA method uses the validated set of Performance Management Indicators from the contractor to provide a future prediction of performance based on past performance evaluations. The performance management system was then used to analyse and interpret data of two subcontractors from recently completed projects.

The contractor provided performance evaluations from a series of 5 recently completed projects from two comparable subcontractors. Using the RPA method, the results suggest that Subcontractor 1 can provide future performance of 83.77-86.28% and Subcontractor 2 can provide an output of future performance of 63.55-65.39% based on a confidence level of 95%. The results suggest that quality is ranked amongst the top PMIs with both contractor and subcontractors survey participants respectively. The case study also identified that not all Performance Management Indicators are suitable in assessing subcontractors on a project specific practical completion application and further refinement of the system is recommended in future work. Subsequent feedback and statistical results of the case study suggest that this performance management system has relevance within the industry and could be adopted within the industry as a powerful tool for principle contractors to assess subcontractors within the construction industry.

Disclaimer

The Council of the University of Southern Queensland, its Faculty of Health, Engineering & Sciences, and the staff of the University of Southern Queensland, do not accept any responsibility for the truth, accuracy or completeness of material contained within or associated with this dissertation.

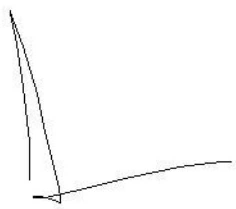
Persons using all or any part of this material do so at their own risk, and not at the risk of the Council of the University of Southern Queensland, its Faculty of Health, Engineering & Sciences or the staff of the University of Southern Queensland.

This dissertation reports an educational exercise and has no purpose or validity beyond this exercise. The sole purpose of the course pair entitled "Research Project" is to contribute to the overall education within the student's chosen degree program. This document, the associated hardware, software, drawings, and other material set out in the associated appendices should not be used for any other purpose: if they are so used, it is entirely at the risk of the user.

Certification

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.



Nicholas Linnan

U1021864

Acknowledgements

I would like to thank Dr Vasantha Abeysekera for the supervision provided throughout my research project. The consultations and time that was invested from brainstorming to the finished product is greatly appreciated.

The contractors representatives and the subcontractors that participated within the case study also should be acknowledged for their support and understanding. Your assistance has helped provide relevance to this research project.

Finally, I would like to thank Lilly Paterson for all your support over the years, without you I wouldn’t be where I am today. Thank you for everything that you have done for me.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

This chapter provides an overview of the research project including a background on the topic as well as defining the clear objectives of the research. Scope and limitations will also be discussed.

This research project provides an extensive literature review on areas relating to the development of a subcontractor performance management system as well as a clear methodology outlining the processes followed for the literature review and subsequent design and implementation of the performance management system. A case study is also undertaken in order to establish the relevance and validity of the proposed performance management system within the construction industry as well as discussion of results, further refinement of the system required and recommended future work.

1.1 Background

The construction industry worldwide remains one of the largest industries in the world. Nobbs (cited in Kumaraswamy and Matthews, 2000, p.47) stated that subcontractors can account for as much of 90% of the total value of a traditional construction project. Following on from this, Lin (cited in Choudhry, 2012, p. 1353) stated that up to 99% of the works within the Hong Kong housing sector within the late 1980's were subcontracted. There are several reasons for this high volume of subcontracting in the construction industry. Many specialist trades are required on a construction project these days, it is not feasible to employ specialist tradespeople nor is it sustainable to own the plant and equipment required to deliver these specialist trade works, thus, these works are subcontracted on an as required basis. Kumaraswamy and Matthews (2000) stated that lowest price criteria is still the most common approach to subcontractor selection and carries risks into the project such as missed scope, poor measuring or estimating methods, subcontractor strategy (to obtain variations form the contractor) as well as poor materials or insufficient labour allowed for in the subcontractors tender price.

Issues like this are the reasons there has been a shortfall identified within the construction industry with respect to subcontractor selection, engagement and evaluations. This research project aims to identify these issues and counter them by creating a functional performance management system that principle contractors can use to select subcontractors.

1.2 Aims

The overall aim of this research project is to investigate the creation of a functional performance management system that principle contractors can use to assess subcontractors. This will be achieved through 3 sub aims:

1. Understand relevant literature for the design of a performance management system
2. Develop a guideline for the design of a performance management system
3. Use the guideline and literature research in sub aims 1 and 2 to establish the performance management system's relevance within the construction industry

1.3 Objectives

In order to achieve the project aim it is necessary to achieve the following:

A. Understand relevant literature for the design of a performance management system. This will be done by:

1. Identify need for a subcontractor performance management system
2. Identify what is performance management, specifically performance management within the construction industry
3. Investigate what are performance management indicators.
4. Research how subcontractors and builders respectively are licenced within Australia to determine if there is any relevance to a subcontractor performance management system.
5. Research performance management criteria to determine key factors that will influence the development of the subcontract performance management system.
6. Evaluate whether subcontract past performance can be an indicator of future performance.

7. Explore the different types of performance management evaluation methods and determine the most appropriate method to utilise within the performance management system.
8. Understand potential frameworks to be used for the development of the performance management system.
9. Explore the benefits of a subcontractor performance management system.

B. Develop a guideline for the design of a performance management system. This will be done by:

1. Identifying suitable frameworks
2. Selecting a suitable framework
3. Establishing its relevance

C. Use the guideline and literature research in sections A & B to establish the performance management system's relevance within the construction industry. This will be done by:

1. Utilising the system through the use of a case study.
2. Assess the results of the case study to establish the system's effectiveness.

1.4 Scope and Limitations

It should be noted that the format and layout of a subcontractor database is not covered under the scope of this research project. This is deemed as a contractor specific document and is subject to the principle contractors Information Technology (IT). The intent of the performance management system is to integrate within a principle contractors existing subcontractor management system.

The case study also cannot be run in real time due to time constraints so data from a range of recently completed projects will be used as a means to gather sufficient data for performance evaluations of subcontractors.

Chapter 2: Literature review

2.1 Introduction

In order to investigate the development of a subcontractor performance management system, it is necessary to undertake an extensive literature review on the subject. While performance management systems within the construction industry are not uncommon, this type of performance management system has been investigated and results have revealed that some adopt ad-hoc systems but details are vague and difficult to assess. As such, peer reviewed journal articles have been the main type of criteria searched for authenticity on the topics of construction performance management and subcontractor performance and evaluation.

2.2 The need for Subcontractor Performance Management System

The Building and Construction Industry is a vastly competitive environment, not only in Australia but around the globe. During business cycles of economic growth, downturn, recession and recovery, according to Schermerhorn (2011), the building and construction industry has seen overall growth and remains one of the largest industries in the world. Depending on the format of the project, exist some forms of entities that integrate to successfully to deliver a finished product, whether its clients, developers, government bodies, principle contractors or last but not least subcontractors, all of these entities can claim a valid stake within a construction project.

Statistically, subcontractors are the biggest stakeholder within the Building and Construction Industry. Nobbs (cited in Kumaraswamy and Matthews, 2000, p. 47) had indicated that subcontractors can account for as much as 90% of the total value of a construction project and credited more dependence on subcontractors 'on increasingly sophisticated technology-based products' as a reason for this. Matthews (cited in Kumaraswamy and Matthews, 2000, p. 47) shared this same opinion and believed that the high volume of subcontracted work was due to the increase in complex technology-based products that require 'a high degree of design, manufacture, installation and commissioning skills that have not been readily available…from the main contractors organization'. Jamieson (cited in Kumaraswamy and Matthews, 2000, p. 47) believed that the high use of subcontractors in construction is due to 'increased complexity of both construction of buildings and the orgainizational relationships'.

Kumaraswamy and Matthews findings are not isolated; Hinze and Tracey (cited in Choudhry, 2012, p. 1353) concurred with their findings by stating the 80-90% of construction works is performed by subcontractors. An inability to perform adept specialist tasks was identified as the main reason for principle contractor's subcontracted works out. These high subcontracting statistics within the construction industry can be traced back to 1987 when Lin (cited in Choudhry, 2012, p. 1353) stated that 99% of works within the Hong Kong housing sector are subcontracted.

As the subcontracting practice is the popular choice in delivering projects by principle contractors the reasons behind this selection of project delivery would appear to be common throughout the industry. Choudhry et al. (2012) states that reasons for subcontracting are:

- Principle contractor cannot afford full time employment of tradespeople within specialised trades
- Note feasible for principle contractors to own and operate plant and equipment required for specialised trades due to their limited use on projects. Due to this, subcontractors are able to carry out works more efficiently and a lesser cost.

Mbachu (2008) also stated reasons for subcontracting include but not limited to:

- Expected higher quality of work as subcontractors are specialists in their respective field
- Principle contractor transfers risk of scoped work to the subcontractor to manage due to specialised experience.
- Labour force is reduced for principle contractor due to the works being undertaken by subcontractors as the principle contractor then manages the subcontractor

Whilst there are obvious benefits for subcontracting works from principle contractors, given the high volume of works that are subcontracted, this process is not perfect and there are issues that exist within the industry.

The common approach to awarding a subcontract within the construction industry is based on lowest price criteria. While there may be benefits to awarding on lowest price, there are shortfalls. Kumaraswamy and Matthews (2000) state that the lowest price within a select set of prices may be inaccurate and as such the price is lower due to factors such as missed scope or poor measurement and estimating methods. It is possible that the pricing has been submitted this way as a subcontractor's strategy to gain variation payments as they have identified issues with the tender documents. Quality would also come into question, if poor quality materials or insufficiently qualified labour is used, and then this could be factors that need to be considered. If the subcontractor's tender price is cheaper than their competitors by a substantial amount (say 10%) then awarding subcontract based on lowest price would carry a degree of risk to the principle contractor.

Choudhry et al. (2012) took a statistical approach to identifying problem areas of subcontracting and interviewed a series of experts in their respective fields within the Pakistan construction industry. Their findings indicate that the main problem areas of subcontracting are quality, progress on site and a general lack of cooperation by the subcontractor. Interestingly, the interviewees also revealed that subcontractors tend to take risks because of the lack of business knowledge. With respect to tender submissions, subcontractors within Pakistan often tender projects without thoroughly evaluating all the documentation. This relates to Kumaraswamy and Matthews findings about lowest price criteria being inaccurate carrying risk with acceptance of these tenders.

Enhassi, Arain and Tayeh (2012) undertook a study to identify major causes of problems between contractors and subcontractors in the Gaza Strip. They also conferred with Kumaraswamy and Matthews by stating the construction industry within the Gaza Strip is a competitive environment 'that is being driven by a lowest cost award system' (Enhassi, Arain and Tayeh, 2012). Issues such as poor quality and late project delivery have been attributed to this approach to subcontract award. They also used a range of statistical analysis, literature research and a pilot study involving construction personnel to rank the issues as a result of subcontracting practises that exist within the Gaza Strip. Table 2.1 illustrates their findings.

Non adherence to contract conditions was ranked as the main issue followed by delay of the works behind time schedule then non adherence of the subcontractor to the time schedule. Lack of quality construction work was fourth followed by neglecting the instructions of the main contractor as fifth. Sixth was a shortage of skilled labour from the subcontractor then a failure to preserve and take care of materials at seventh. Exhausting the plant and resources came in at eighth, absence of subcontractor from site was ninth and finally partnering the works to another subcontractor without approval from main contractor was tenth. Enhassi, Arain and Tayeh also correlated their findings from the pilot study of these problems to their literature findings from published articles of other industry experts which are shown in Table 2.1. It is interesting to note that the highest ranking problems (relative ranking 1-6) caused by subcontractors found from the pilot study of industry experts also aligns with the findings from their literature reviews. This could suggest that relative ranking items 1-6 are industrial problems which relate to different organisation's and cultures whereas problems 7-10 may be culturally specific to the Gaza strip.

Causes of problems	**Relative Ranking**	**Literature Findings**
Non-Adherence to the conditions of the contract	1	Al-Hammand, 1993
Delay of the works behind the time schedule	2	Al-Hammand,1993 Sambasivan and Soon, 2007
Non-adherence of the subcontractor to the time schedule	3	Al-Hammand,1993 Sambasivan and Soon, 2007
Lack of construction quality work	4	Othman, 2002; Al-Hammad, 1993; Al-Hazmi, 1987; Huang et al. 2008
Neglecting the instructions of	5	Al-Hammand, 1993

the main contractor		
Shortage of skilled labour with the subcontractor	6	Enshassi et al 2007 & Al-Hazmi, 1987
Failure to preserve and take care of materials	7	
Exhausting the plant and resources of the main contractor	8	
Absence of the subcontractor from site	9	
Partnering the works to another subcontractor without getting approval of main contractor	10	

Table 2.1 Causes of problems by subcontractors (Enhassi, Arain and Tayeh, 2012)

Principle contractors have identified with these issues and in recent years have been proactive in improving their quality assurance system's in an attempt to curve some of these recurring issues such as program delay, quality and non-adherence to contract conditions. Prequalification has been recommended as a solution to some of these problems in recent years. Prequalification in the industry is predominantly used by top tier construction companies and government bodies as a means of prequalifying principle contractors. Government bodies such as Department of Housing and Public Works QLD, Department of Education Training and Employment (QLD Government, 2014), Tasmanian Government Procurement Section (Tasmanian Government, 2014) and New South Wales Government Transport Department (NSW Government, 2014) all have prequalification system's in place that requires principle contractors to register themselves and qualify under parameters set by the respective government bodies.

Prequalification between principle contractor and subcontractors is not a common practice, although particular specialist subcontractors are required for HVAC and specialist mechanical services such as escalators and elevators (Abeysekera, 2015). However, to date no such system has been discovered by the author. Choudhry (2012) also concurred with these findings, stating that ‘A major finding of this research [paper] is that there is no prequalification registration or system in place for the performance evaluation of subcontractors…”. While there are benefits in prequalification system as these form part of Quality Assurance systems of clients, government bodies and top tier contractors; the format of prequalification does not seem to suit the principle contractor/subcontractor relationship. Prequalification does not have a major emphasis on performance; rather prequalification is more concerned with selecting contractors who have the capability to undertake projects. ***A better approach to subcontractor selection would be to implement a subcontractor performance management system.***

As such, a performance management system is more suited to the subcontractors, as a fully functional performance management system could help to assess subcontractors against performance management indicators. These performance management indicators could be specific to the industry or more specifically to the organisational culture in which the performance management system resides. Palaneeswaran and Kumaraswamy (2000) advocated the use of a performance management system for subcontractors promoting a central subcontractor performance management system would assist principle contractors in assessing subcontractor performance and act as a framework for recording, comparing and benchmarking a subcontractor’s performance. This information could then be used to assist the principle contractor in selection of suitable subcontractors based on past performance for future projects. Furthermore, a functional performance management system for subcontractor selection could also assist in marrying the right subcontractor, for the right job. This will be investigated further in the next section.

2.3 Performance Management

An internet based search will define performance management as ‘an assessment of an employee, process, equipment or other factor to gauge progress toward predetermined goal's (Business Dictionary, 2015). Another view would be to view performance management as a series of planning, monitoring and evaluation techniques that may facilitate success. The role of performance management has been widely researched in various industries which have led to the development of key philosophies and frameworks such as Key Performance Indicators (KPIs), benchmarking and Total Quality Management (TQM) etc. All of these philosophies rely on implementation of valid performance measures and this is best described by Figure 2.1

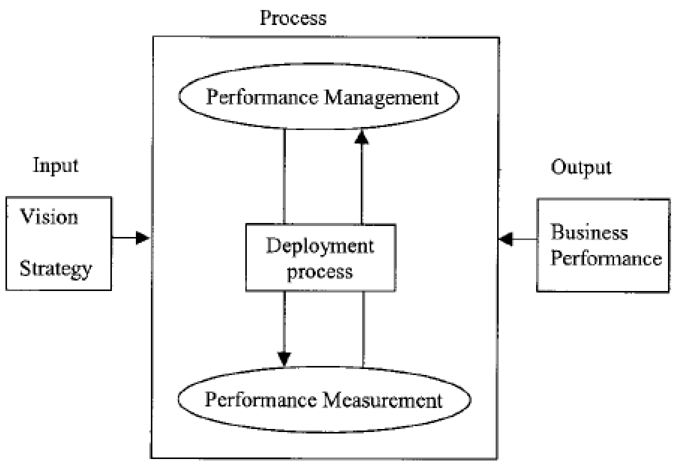


Figure 2.1 The performance management/measurement process (Kagioglou et al, 2001)

An organisation's vision strategy will differ depending on values, size, culture, location etc. These will shape the performance measurements and management techniques and will result in an output. The success of this output will be dependent on the deployment process of measurement and management techniques, valid assessment criteria etc.

The construction industry is unique in nature as every project is different, and philosophies will differ from organisational culture, size etc. While performance management has been the subject of much research in recent years, Costa et al. (2006) states that

"performance measurement data have not been widely identified and collected in construction companies…As a result, information on the performance on the construction industry as a whole tends to be scarce…only a few have performance measurement processes, which should

provide key support for decision-making processes...Moreover, some companies have too many measures [Not valid]…"

If performance measures are non-existent or not valid, then performance indicators tend to be centred on financial success (Kagioglou, et al. 2001). While this is useful to an extent, it is a measure of past performance and encourages short term thinking, demonstrates a lack of strategic focus within an organisation and does not promote any continuous improvement. These are then known as 'lagging' indicators and puts organisation's into a reactive mindset rather than a proactive one which would be desirable. Bassioni et al. (2005) states that with respect to performance management within the construction industry "…in developing a comprehensive framework, it is only logical to build upon the principles of the existing frameworks…" Concurring with the research of Costa et al (2006), Bassioni et al. (2005) and Kagioglou et al. (2001), performance management system's implementation within the construction industry is scarce, however several performance management system's relating to the construction have been identified being the National Benchmarking system for the Chilean Construction Industry (NBS-Chile), the SCORE program from the Construction Industry Development Board in Malaysia, the Performance Assessment Scoring System (PASS) in Hong Kong and the Singapore List Of Trade Subcontractors (SLOTS) scheme.

Benchmarking has become a popular choice for performance management within recent years, in particular the manufacturing industry. Accordingly to Costa et al. (2006), NBS-Chile was created in 2000 by the Corporation for Technical Development (CDT) of the Chamber of Construction and others. It is a program that has two initiatives, firstly performance measurement in the construction industry and secondly benchmarking 'clubs' that consist of groups of construction companies in Chile that share information and experiences to compare their performance in various different ways. These 'clubs' have been instrumental in the delivery of the NBS system within Chile. Initially, extensive literature reviews of the construction industry were under taken and 30 performance indicators were discussed and subsequently reduced down significantly based on the individual needs of the construction companies. More recently, the benchmarking club undertook a study to measure the effectiveness of the NBS initiatives. Table 2.2 illustrates their findings of their first initiative of performance measurement within the construction industry.

Positive Factors	**Negative Factors**
Comparison among competitors	Exclusive use of lagging measures
Guidance concerning the implementation and use of measures	Excess of measures
Fast transmission of information	Overload of information to be collected
Use of measures in real time	Collection of data imposed by top manager
	Comparison between projects that are very different
	High cost low benefit
	Lack of connection between measures and practices

Table 2.2 Findings of study of effectiveness of NBS first initiative

Based on the study's findings, it can be seen that the NBS provides benefits such as comparison among competitors, guidance of the implementation and use of measures, fast transmission of information and most importantly the measures utilised are in 'real time', which is an instantaneous action (Business dictionary, 2015). This is important as the measures are classed as 'leading' and not lagging measures. However, there were several negative factors which appear to hinder the system's performance. Some of these include exclusive use of lagging measure, excessive measures, overload of information, comparison of projects is very different, high cost low benefit ratio and a lack of connection between the measures and practices. Based on this it can be seen that the NBS system while has benefits as a benchmarking system in particular the measures being leading indicators, however, the implementation appears to fall short which is hindering the success of the NBN system. While the performance measures are tweaked based on the individual construction companies organisational culture which is beneficial, it appears that this system has more of a focus on the national construction culture of Chile and thus a 'one size fits all' approach to their benchmarking system may not be the most effective implementation process.

The Construction Industry Development Board (CIDB) is a government body that chairs the construction industry within Malaysia and in 2006 were instrumental in developing the Construction Industry Master Plan 2006-2015. The main goal of this master plan was to develop a comprehensive set of performance measures for the Malaysian construction industry for 2006 and use these as a benchmark for performance throughout the master plans lifecycle until 2015 (Chan, 2009). Chan used the balanced scorecard approach to assess performance and used the categories such as specific financial measures, predictability of time and cost measures, internal perspectives dealing with research & development and learning & growth which measured employee turnover as well as training days.

The CIDBs introduction of the Evaluation Capacity and Capability of the Contractor (SCORE) program is aimed "to assess the capabilities of local contractors in Malaysia and to enhance the image of the construction industry in accordance with the requirements of the construction industry master plan" (CIDB, 2012). The objectives of this program are:

- *To give recognition to contractors who have the ability and achievements in the field of financial management*
- *To identify weaknesses in the CIDB contractor and help set up programs that can increase the capacity and skills of the contractor.*
- *To develop industry profiles for the identification of the level of ability of local contractors and measure benchmark between contractors both inside and outside the country.*
- *To assist the client in the selection of the contractor that caliber.*

(Source: CIDB, 2012)

Performance measurement is based on performance of contractor, financial capacity, technical capacity, project management skill, procurement management, best practice and overall management capability (CIDB, 2012) and is based on a 5 point Likert scale. These measures were influenced by international benchmarking measures, primarily from the UK

(Chan, 2009) and have been modified to suit the Malaysian culture, this concurs with the NBS method of tailoring measures to suit cultures be it organisational or national culture.

Chan (2009) undertook a performance measurement of the Malaysian construction industry after the implementation of the master plan and the SCORE program. The results are peculiar, as there it is seen that there is an increase in innovation, overall quality and a prediction of increased productivity around the industry. However, there are several negatives to the system including low safety performance, low R&D, low number of contractors certified under the SCORE program for quality, environmental and health & safety standards. Chan also notes that nearly half of the construction workforce is unskilled. Surprisingly, the industry has seen growth and remains profitable due to increase of overseas projects. The SCORE system is an unusual case as whilst the industry remains profitable and there appears to be growth within the export and offshoring markets, it appears that the domestic contractors are not benefiting from the SCORE systems implemented by the CIDB. The implementation of this system again like the NBS appears to be at a national level and it can be argued that these benchmarks set to the industry are not relevant given the high volume of unskilled labour within the industry.

1990 saw the introduction of the Performance Assessment Scoring System (PASS) by the Hong Kong Housing Authority (HKHA), and in 1991 saw the implementation of the system. The system is aimed at measuring building contractors who contract through HKHA, which is the governing body for the public housing sector works within Hong Kong. The objective of the system is to incentivise contractors who perform within the upper quartile of the overall score to grant more tendering opportunities (Tam et al. 2000). The PASS system is very simple yet effective and in lieu of Likert scales to measurement uses a yes/no evaluation method. The PASS assessment is undertaken by the HKHA each month for all active projects, the contractors being assessed are not given more than a half days' notice for the assessments and there is a very strict approach to the assessment.

The PASS system is broken into 3 main assessment criteria, <u>input</u>, <u>output</u> and <u>maintenance</u> assessments. **Input** assessment has a focus on management skill and communication of the contractor. **Output** assessment has a focus on the finished product that the contractor delivers, and has weighted criteria such as structural work with a weighting of 35%, architectural work with a weighting of 35%, external work with a weighting of 10% and general obligations (contract adherence, safety etc) with a weighting 20%. **Maintenance** assessments are concerned with the defects liability period and the overall operation of the building when occupied (Tam et al. 2000).

The PASS system while simple and effective in nature takes a different approach to its implementation, it appears to provide real time data and the performance measures appear to be leading indicators which is highly beneficial for any form of performance management. It is a system implemented at a national level yet is still implemented at the contractor and subcontractor level on a monthly basis which is not seen in the NBC and SCORE systems. Assessors provide no more than a half day notice of the time of the inspection which ensures that contractors and subcontractors have minimal time to prepare for inspections, the aim of this is to ensure year round compliance to the PASS system. It appears that there is an underlying approach to TQM within the PASS system and the incentive of further opportunities for performing contractors is excellent. The yes/no evaluation system is simple and takes a very strict approach, while this appears to be effective it may also be a contributing factor to some of the downfalls of the PASS system.

There are problems with the PASS system, Tam et al (2000) undertook extensive data analysis of raw data provided by the HKHA and noted that the actual achievements fall below original expectations for the system. Reasons for this lie with the quality output of the assessment criteria. It appears that only larger contractors can achieve the desired quality output as deemed acceptable by the HKHA and that smaller contractors are unable to get the tick of approval. Also in times of private sector growth, due to the strict PASS system criteria, contractors show less interest in the public sector and focus their attention to the private sector. Tam et al (2000) also goes on to summarise the PASS scores do not show an upward trend which would signalise that quality is a major factor in any performance management system.

The Singapore's Contractors Association Limited (SCAL) commenced the registration of subcontractors in 1992 using a scheme called the Singapore List of Trade Subcontractors (SLOTS). The aims of the SLOTS scheme are to "identify and accredit a core of active trade subcontractors in the construction industry who are able to meet the quality and productivity needs of the industry" as well as "to provide a list of recommended and accredited trade subcontractors". For subcontractors to register there are prerequisites such as company numbers established, taxation and statutory requirements fulfilled etc. Subcontractors were also required to have at a minimum 10% of the workforce certified as skilled workers. Registration was broken into 3 subsections being, civil/structural, architecural & finishing and mechanical/electrical. Under these headings the subcontractors are further broken into their specific disciplines. SLOTS also do not delineate between public and private sectors unlike the PASS system (Loh and Ofori, 2000). The SLOTS scheme bears some familiar qualities to the Queensland Building and Construction Commission (QBCC) that provides subcontractor licencing in Queensland, Australia. QBCC licencing is discussed further in section 2.5.

Benefits of the SLOTS schedule are that the accredited list of subcontractors is distributed to public and private sector professionals and similarly to PASS those who are performing exceptionally are rewarded with more opportunities. Some problems noted are that contractors and subcontractors do not like having their business activities traced for taxation and foreign worker levy purposes. It is identified that subcontractors who are not SLOT registered are still able to obtain contracts through contractors, however it should be noted that the SLOTS scheme is not a prequalification, but a scheme aimed at improving quality and productivity of subcontractors within Singapore (Loh and Ofori, 2000).

Loh and Ofori (2000) undertook a study to provide the SLOTS scheme improved performance of contractors and subcontractors respectively. It was noted from interviews and data analysis that contractors believed that SLOTS accredited subcontractors performance was increased through the successful implementation of the SLOTS scheme. Loh and Ofori (2000) concluded in their study that the introduction of the SLOTS scheme found evidence to suggest that registration of subcontractors has resulted in improved performance across time, cost and quality factors. They also recommend that contractors establish a well-defined policy for the selection of subcontractors as a solution to pitfalls that exist in the construction industry. This is supplemented by Cooke and Williams (2013) who state "…the main contractor should consider adopting a policy of creating good relationships with a small group of reliable subcontractors…often the main contractor's reputation may rely solely on the excellence of his subcontractors' performance".

Based upon extensive literature reviews of performance management, it appears that the PASS system and the SLOTS scheme seem to be the most effective with respect to achieving higher levels of performance from subcontractors within the construction industry. While PASS and SLOTS are implemented at a national level, the NBS and SCORE scheme identify that **performance measures need to be tailored to organisations specifically due to the variances in organisational culture, value, goals and size etc**. Loh and Ofori's conclusions supported by Cooke and Williams have merit as up to 90% of works are subcontracted, the principle contractors reputation will largely depend on the quality of the subcontractors that are used. Providing a system that can be introduced at the principle contractor's level in order to identify suitable performing subcontractors would be highly desirable.

2.4 Performance management indicators

The literature review has established that all performance management systems require a set of performance management indicators. These indicators are the key items that are used to assess criteria, whether it is a benchmarking, KPI or hybrid performance management system, the indicators will be the crux of the system. It is important to ensure that the performance management indicators are valid and reliable given the application. This literature review is concerned with performance management indicators of subcontractors that principle contractors can use to assess their performance within the construction industry. Extensive literature was reviewed on subcontractor performance management indicators; Table 2.3 provides a summary of findings.

	Performance Management Indicators	**Kumaraswamy and Matthews 2000**	**Cooke & Williams 2013**	**Okoroh and Torrance 1999**	**Cheng and Wu 2012**	**Ng and Skitmore 2014**	**Sommerville and Robertson 2000**	**Doloi 2009**	**Costa et al 2006 (NBS Chile)**	**CMG1001 2011**	**Loh and Ofori 2000 (SLOTS)**
1	Design Ability	X									
2	Partnering (with main contractor) Experience	X									
3	Level of Understanding of Scope	X									
4	Value Engineering Thoughts	X									
5	Response to Construction Feedback	X									
6	Reaction to 'Realistic Costs'	X									
8	Quality Awareness										
7	Previous Experience as subcontractor		X	X				X			
8	Communication		X	X		X	X				
9	Financial Capacity		X	X	X	X		X			
10	Technical Capability		X	X				X			X
11	Reputation		X								
12	Subcontractors workload		X					X			
13	Clients Acceptance of Subcontractor		X					X			
14	Tender Price		X	X			X	X			X
15	Quality	X	X	X		X	X	X			X
16	Subcontractor References		X	X							
17	Geographical Location			X				X			
18	Safety			X	X	X	X	X	X		X
19	Meeting Attendance			X		X					
20	Adherence to Construction Program			X	X	X	X	X			X
21	Honesty and Reliability			X	X		X				
22	Previous Experience with main contractor			X		X					
23	Construction Methodology for site work	X			X				X		
24	Cooperativeness with main contractor				X						
25	Material Wastage on site				X		X				
26	Defects Liability Servicing				X			X			

27	Collaboration with other Subcontractors				X						
28	Workspace Cleanliness				X						
29	Management Ability				X						
30	Environmental Impact					X	X				
31	Variation Claims					X					
32	Resource Control (Material, plant, equipment etc)		X			X		X			
33	Contractual Risk (BCIPA & Construction claims etc)		X								
34	Training and Development of Employees						X	X			
35	Employee Satisfaction and involvement					X	X	X			
36	Flexibility in critical activities							X			
37	Flexibility in non-critical activities							X			
38	Post contract attitude				X			X			
39	Willingness to tender							X			
40	Knowledge of construction regulations							X			
41	Failure in timely progress claims							X			
42	Past records on conflicts and disputes							X			
43	Successful past projects							X			
44	Project adaptability							X			
45	Employee turnover							X			
46	Union knowledge and relationship							X			
49	Current workload commitment							X			
47	Cost Deviation from tender pricing								X		
48	Deviation of construction practical completion date								X		
49	Efficiency of direct labour								X		
50	Effectiveness of works planning								X		
51	Commitment Reliability (e.g. Keeping their word)									X	

Table 2.3 Summary of findings for subcontractor performance management indicators based on literature review

Kumaraswamy and Matthews (2000) researched improved subcontractor selection employing partnering principles and their performance management indicators. Cooke and Williams (2013) published a checklist for subcontractor selection at prequalification stage. Okoroh and Torrance (1999) created a model for subcontractor selection in refurbishment projects, their performance management indicators were a result of their SSARC interface network. Cheng and Wu (2012) proposed a Subcontractor Rating Evaluation Model (SREM) assessing subcontractor performance using Evolutionary Support Vector Machine Interface (ESIM). They used analytics and literature reviews to identify ‘influence factors’ which became evaluation factors for their model in subcontractor evaluation. While their rating model does not fit the profile of this performance management system, it does provide good performance management indicators which could be used for subcontractor assessment. Ng and Skitmore (2014) developed a framework for subcontractor appraisal using a balanced scorecard. Their proposed scorecard had selection criteria as a result of their findings. Sommerville and Robertson (2000) also used a balanced scorecard approach to benchmarking for total quality within the construction industry. Doloi (2009) analysed prequalification criteria for contractor selection and their impacts on project success. Doloi (2009) identified extensive attributes and used industry survey to provide rankings on the findings and identify the relative importance of each attribute.

The performance management indicators listed in Table 2.3 identify suitable indicators that could be used to assess subcontractor’s performance. However, performance management is not a ‘one size fits all’ approach. Thakkar (2006) stated “Each organisation is unique and so follows its own path…” this is especially true within the construction industry with respect to principle contractors. Principle contractors vary in organisational mission statements, values, policies and cultures. Geographical location also plays an important role as national culture will also influence the selection of performance management indicators. Whether the principle contractor operates in the top tier or mid-tier will affect their approach to subcontracting as well as which sector they operate in (public or private) etc. This will all impact the finished product or an organisation’s performance management system of subcontractors and as such it would be best if a framework was developed that could be used for principle contractors worldwide. However, as Costa et al (2006) discovered in the NBS for Chile, the performance management system framework could be tailored to suit the individual needs of the construction companies.

2.5 Licencing and performance management

Australian construction businesses that wish to undertake construction work (above certain financial thresholds) are required to be licenced by relevant governing bodies in their operating states (Falta and Gallery, 2011). In Queensland the relevant governing body for construction work is the Queensland Building and Construction Commission (QBCC) formerly known as the Queensland Building Services Authority (QBSA) which was established in 1991. According to Falta and Gallery (2011) “among the Australia States, the QBSA [QBCC] construction industry regulatory framework is considered to be a leader in the field that provides a model for the other states”. The QBCC’s vision is simple, to be ‘recognised as the best and most respected regulatory service provider in Australia’ (QBCC, 2015). The literature review aims to investigate this framework for construction businesses in Queensland (QLD) to determine any relevance to a subcontractor performance management system. Note that as the research project is undertaken in QLD, the scope of this section will be limited to the state of QLD only.

While the QBCC covers licencing for builders, building surveyors and certain types of designers this literature review is concerned with subcontractors licencing. The QBCC (2015) states that all individuals or companies that wish to ‘carry out, undertake to carry out or supervise’ (QBCC, 2015) construction works valued at over $3,300 including GST (labour and materials inclusive) must hold the appropriate licence relating to the construction work. Table 2.4 illustrates the types of trade contractor licences available. Licence classes all have scopes of work that the licence permits the trade contractor to undertake; due to this it is not uncommon for some subcontractors to have licences that cover multiple disciplines. It should be noted that there are some licence classes that are missing from the QBCC table below such as demolition, structural metal fabrication & installation and structural landscaping.

	Trade Contractor
AHD	Air Handling Duct Installation
BSP	Brick and Segmental Paving
BLB	Bricklaying and Blocklaying
CM	Cabinet Making
CON	Concreting
CP	Carpentry
DN	Drainage
FFEL	Emergency Lighting+
FOEL	Emergency Lighting – Occupational
FFEP	Emergency Procedures
FOEP	Emergency Procedures – Occupational
FFDS	Fire Detection, Alarm and Warning Systems+
FODS	Fire Detection, Alarm and Warning Systems – Occupational
FFHH	Fire Hydrants and Hose Reels+
FOHH	Fire Hydrants and Hose Reels – Occupational
FFPS	Fire Pumps+
FOPS	Fire Pumps – Occupational
FFSP	Fire Safety Professional
FOSP	Fire Safety Professional – Occupational
FFWC	Passive Fire Protection – Fire and Smoke Walls and Ceilings+
FOWC	Passive Fire Protection – Fire and Smoke Walls and Ceilings – Occupational
FFPJ	Passive Fire Protection – Fire collars, Penetrations and Joint Sealing+
FOPJ	Passive Fire Protection – Fire collars, Penetrations and Joint Sealing – Occupational
FFFD	Passive Fire Protection – Fire Doors and Shutters+
FOFD	Passive Fire Protection – Fire Doors and Shutters – Occupational
FFPE	Portable Fire Equip.& Hose Reels (Hose Reels Down Stream of Stop Cock ONLY)+
FOPE	Portable Fire Equip.& Hose Reels (Hose Reels Down Stream of Stop Cock ONLY) – Occupational
FFSH	Special Hazard Suppression System+
FOSH	Special Hazard Suppression System – Occupational
FFSS	Sprinkler and Suppression Systems (Reticulated Water Based)+
FOSS	Sprinkler and Suppression Systems (Reticulated Water Based) – Occupational
FCHS	Floor Finishing and Covering (Hard Sector)
FW	Foundation Work (Piling and Anchors)
GFT	Gasfitting
GGA	Glass, Glazing and Aluminium
IR	Irrigation
JN	Joinery
MFG	Metal Fascias and Gutters
NSMF	Non Structural Metal Fabrication and Installation
PNAD	Painting and Decorating
PDW	Plastering Drywall
PSD	Plastering Solid
PDN	Plumbing and Drainage
RALD	Refrigeration, Air Conditioning and Mechanical Services Including Limited Design
FAUD	Refrigeration, Air Conditioning and Mechanical Services Included Unlimited Design
RWC	Roof and Wall Cladding
RFT	Roof Tiling
SCF	Site Classifier+
SCG	Sheds Carports and Garages

Table 2.4 List of trade subcontractor categories available for QBCC licencing (QBCC, 2015)

According to the QBCC (2015), the terms "carry out, undertake to carry out or supervise" are defined by the following:

- *Directly or indirectly causing building work to be carried out*
- *Providing advisory, administrative, management or supervisory services in relation to building work; or*
- *Entering into a contract or submitting a tender for building work or offering to carry out building work.*

In order for individuals or businesses to be QBCC licenced in any class an application form for licencing is required to be completed and applicants are required to demonstrate technical qualifications, managerial qualifications, experience and financial qualifications.

<u>Technical qualifications</u> for each licence type are listed out in the scopes of work applicable to each licence. Typically a trade level qualification e.g. Certificate III in Waterproofing will qualify the individual in this respect. If a formal qualification is not held then a 'Recognition of Prior Learning' (RPL) could make the applicant eligible, the RPL for a licence type would typically be assessed by a Register Training Organisation (RTO) who would certify the individuals previous experience and provide a recommendation of eligibility.

<u>Managerial qualifications</u> are required through the completion of an approved managerial course. Typically most TAFE collages that offer Vocation Education training will offer the managerial course that is deemed to satisfy the QBCC requirement for a managerial qualification.

Experience is one of the more important aspects of licencing. The scopes of work for each licence class provide the prerequisite for each licence type. Typically 2-4 years of field experience is required as a minimum. Apprentices undertaking their Vocational Education training in the field can substantiate their time as an apprentice as experience.

<u>The financial qualification</u> of QBCC licencing is assessed on the following criteria:

- *Maximum Revenue*
- *Net Tangible Assets*
- *Current Ratio*
- *Payment of Debts*
- *Financial Monitoring*
- *Professional indemnity insurance.*

(Source: QBCC, 2015)

Maximum revenue “means the maximum Revenue from all sources a licensed entity may earn in each financial year. The Maximum Revenue issued to a Licensee applies to the licensed entity in combination with all trusts or partnerships through which it is trading” (QBCC, 2015). Each licence class has different categories that relate to the Annual Allowable Turn Over (AATO). The AATO of each licence category provides the limit of turnover that the individual or business can undertake under the category of their particular licence class. The maximum revenue is directly related to the AATO.

It is a requirement for QBCC licencing that ‘applicants and licensees must have sufficient Net Tangible Assets (NTA) in their own right sufficient for the higher of the level of Maximum Revenue or the actual Revenue being generated… [Refer Appendix 2]. The NTA of an applicant or licensee must be at least $0’. (QBCC, 2015). The NTA is calculated by the following:

NTA = Assets – Liabilities – Intangible Assets – Disallowed Assets

Equation 2.1 Calculation of Net Tangible Assets (QBCC, 2015)

The Current Ratio of the individual or business must be at least 1:1 and is calculated by the following:

Current Ratio = Current Assets / Current Liabilities

Equation 2.2 Calculation of Current Assets (QBCC, 2015)

According to the minimum financial requirements for QBCC licencing (2015) the definition of ‘payment of debts’ refers to the following:

“It is a financial requirement that a Licensee must at all times pay all undisputed debts as and when the debts fall due and within industry trading terms. It is also a financial requirement that a Licensee or Applicant must pay all debts as ordered by a Court or Tribunal within 28 days of the order or a longer period if allowed by the Court or Tribunal…. Where a Licensee or Applicant has an unpaid debt, the Commission may require the provision of any documents or evidence deemed necessary to determine whether the Licensee or Applicant meets the Minimum Financial Requirements. The Commission will notify the Licensee or Applicant of a timeframe to provide

the information. Failure to provide the required information may result in the Commission determining the Licensee or Applicant fails to meet the Minimum Financial Requirements."

To continually monitor activity of individuals or businesses, the QBCC requires financial monitoring by all licensees. According to the minimum financial requirements for QBCC licencing (2015) states that:

"It is a financial requirement that a Licensee must prepare and maintain internal management accounts at quarterly intervals in each financial year at a minimum. Licensees are required to submit their internal management accounts if required by the Commission…The Commission may notify any Licensee of the requirement to provide their internal management accounts after the end of a quarter. The Commission will notify the Licensee of the timeframe to provide the information. Failure to provide the required information may result in the Commission determining the Licensee fails to meet the Minimum Financial Requirements."

The final financial requirement for QBCC licencing is the mandatory requirement for professional indemnity insurances in certain licence types. The minimum limits of indemnity are listed in Table 2.5.

Licence Class	Limit of Indemnity Amount
Building design – open	$500,000
Building design – medium rise	$500,000
Building design – low rise	$500,000
Termite management – chemical	$500,000
Hydraulic services design	$1,000,000
Hydraulic services design excluding design of on-site domestic waste water management	$1,000,000
Site classifier	$1,000,000
Site classifier excluding design of on-site domestic waste water management	$1,000,000
Completed residential building inspection	$1,000,000
Passive fire protection – fire doors and shutters – Certify	$1,000,000
Passive fire protection – fire collars, penetrations and joint sealing – Certify, install and maintain	$1,000,000
Passive fire protection – fire and smoke walls and ceilings – Certify	$1,000,000
Special hazard suppression systems – Certify – restricted to gaseous, water mist and reticulated foam proportioning systems	$1,000,000
Special hazard suppression systems – Certify – restricted to chemical and foam special hazard systems	$1,000,000
Sprinkler and suppression systems (reticulated water based) – Certify	$1,000,000
Sprinkler and suppression systems (reticulated water based) – Certify – restricted to commercial or industrial type	$1,000,000
Sprinkler and suppression systems (reticulated water based) – Certify – restricted to domestic or residential types	$1,000,000
Fire pump – Certify	$1,000,000
Fire hydrants and hose reels – Certify	$1,000,000
Portable fire equipment and hose reels (hose reels down stream of stop cock only) – Certify	$500,000
Fire detection, alarm and warning systems – Certify	See 10.3 below
Emergency lighting – Certify	$1,000,000
Fire suppression systems - special hazards*	$1,000,000
Fire suppression systems – special hazards restricted to certification of, and preparation of reports about, certain work*	$1,000,000

Table 2.5 Limits of indemnity amounts for certain licence types (QBCC, 2015)

The minimum financial requirements are quite comprehensive and QBCC operates under a strict framework for licencing. The QBCC also offers a licence search feature on their website which provides information of all licence holders, AATO, address, licence categories amongst other important information. This is a handy tool that principle contractors can use prior to engagement of any subcontractor to ensure that they are appropriately licenced to undertake the work and that the licence is still current.

A review of the QBCC licencing framework demonstrates that the requirements for licencing approval are quite comprehensive. If a subcontractor holds QBCC licence for a particular trade discipline, it will not be a replacement for a performance management system, however, a QBCC licence search will identify if the subcontractor has the relevant experience, managerial skill, technical qualification and financial requirements to at a minimum, be entitled to tender on a project. A QBCC licence check will not replace or contribute directly to a functional performance management database; however, it may form part of a framework that would be required to prequalify a subcontractor to be entered into a database that forms part of a performance management system.

2.6 Past performance vs. future performance

The question of whether subcontractor past performance can be an indicator of future performance is a significant factor in the development of a performance management system. Predicting future performance based on past results is not an exact science and does carry some risk. Eddie Cheng (2014) from the Hong Kong Institute of Education has published a paper relative to this field and states 'using past data to predict the future, however, incurs a certain degree of risk. In order to increase the accuracy of estimation, risk assessment should be incorporated'. This section investigates the work of Eddie Cheng and evaluates whether past performances of subcontractors can be used as an indicator of future performance.

During the course of construction, a project team will determine if a subcontractor is performing or not performing on site. However, the official assessment of their review of a subcontractor on a project is typically done at the end of a project. Some principle contractors do not even conduct official subcontractor reviews and this would be at their detriment. This data according to Cheng (2014) will be the basis of a prediction of a subcontractor's future performance. If a subcontractor's performance rating was known at the beginning of a project, it could substantially improve the success of the project. A literature review has found limited resources on prediction of subcontractor performance. Ng and Tang (2007) proposed a Subcontractor Performance Appraisal Criteria (SPAC), which is useful, however it does not assist is predicting future performance and does not factor in any risk assessment.

If subcontractor performance reviews were undertaken at the completion of a project using performance management indicators as identified in section 2.4, then this quantitive data could be used to input to a performance management database and used to assess the potential future performance of subcontractors. Cheng (2014) presents a process called the Risk Possibility Assessment (RPA) method. The RPA method can provide a prediction of future performance as well as "estimates the level of risk based on past data/information. The level of risk can be seen as the probability that an anticipated performance will not occur in the future" (Cheng, 2014). The RPA uses some basic statistical analysis to determine the future performance of subcontractors:

- Expected value (mean)
- Standard deviation (variance)
- Coefficient of variation
- Range of expected value

The expected value in this application would be the average of the sum totals of the subcontractor's assessment from a subcontractor performance review. This provides an expected value or subcontractors score based on past performance.

The standard deviation identifies how much a set of numbers differs from the expected value and is calculated using equation 2.3. The RPA method identifies the standard deviation with the level of risk e.g. if two subcontractors had similar scores, the one with the lower standard deviation (level of risk) should be selected.

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

Where:

$\bar{X}$ = Sample arithmetic mean

n = Sample size

X_i = i^{th} Observation of the random variable X

$\sum_{i=1}^{n} X_i$ = Summation of all the X_i values in the sample

Equation 2.3: Standard Deviation (MTSU, 2015)

The coefficient of variation (σ/s) is a ratio of the standard deviation to the mean. With reference to the RPA method, is simply shows the general expectation of the quantitive data (i.e. the smaller the value, the higher the prospective performance that could be obtained by the subcontractor)

The range of expected value is also known as the confidence interval and can be set at the discretion of the user and is calculated using equation 2.4. This will provide a range based on past performance that the subcontractor will perform to for future project works.

$$\bar{X} \pm Z \frac{s}{\sqrt{n}}$$

Where:

Z= Figure from z Table for standard normal distribution

s=standard deviation

n=sample size

Equation 2.4: Confidence interval (Boston University School of Public Health, 2015)

The literature review has identified a simple process which can use performance management indicators as quantitive data that can be used to predict future performance of subcontractors. The prediction is based on previous performance and requires an assessment of the risk involved which utilised Chengs (2014) RPA method. Having an understanding of how subcontractors will perform at the beginning of a project could be highly beneficial for a principle contractor. The calculations appear simple in nature and could easily be incorporated into a performance management system.

2.7 Performance management evaluation methods

It is crucial to a performance management system to evaluate the performance management indicators applicable to the organisation. In order for the performance management system to be truly effective, an evaluation method should be selected that will complement the system as a whole. The assessment of subcontractors at the completion of a project will usually be done at the tactical level by the Contracts Administrator in conjunction with the Project Manager so it is important to select an evaluation method that will be simple yet effective for the level of management in which it will be implemented.

The Baldrige award examination is formed using a strict set of performance criteria called the criteria for performance excellence. The goal of the Baldrige award examination is to enhance competiveness and align the organisation's approach to performance management which will result in:

- Delivery of ever-improving value to customers
- Improvement of overall company performance
- Organisation and personal learning

(Evans and Lindsay, 2014)

The Baldrige award examination consists of seven categories of assessment:

1. Leadership
2. Strategic planning
3. Customer focus
4. Measurement, analysis and knowledge management

5. Workforce focus
6. Operations focus
7. Results

(Evans and Lindsay, 2014)

While the Baldrige award examination is used extensively around the world, in particular the USA it appears to be focused at a strategic management level and would require a whole organisational shift in culture in order to fully implement and thus it does not appear to be the suitable to the proposed subcontractor performance management system.

The balanced scorecard (BSC) was first developed in the 1990s by Robert Kaplan of Harvard Business School and David Norton who was a management consultant at the time. Their aim in developing the score card was to bridge *"the gap between the objectives set by senior management and the actions of frontline employees. In recognising some of the weakness and vagueness of previous management approaches, the balanced scorecard provides a clear prescription of what to measure to balance critical perspectives of an organisation"* (Ng and Skitmore, 2014). The BCS approach uses a broad range of indicators such as learning and growth perspective, internal business perspective, customer perspective and financial perspective (Thakkar et al, 2016) and acts as a template framework for an organisation to develop to suit their business and implement at all levels of the organisation. The BSC is widely popular in the construction industry and a number of authors have published research papers implementing its approach. Chan (2009) implemented the BSC when attempting to measure performance of the Malaysian construction industry, Lo, Wong and Cheung (2006) used a BSC to measure performance of partnering projects and Bassioni (2007) used BSC to build a conceptual framework for measuring business performance in construction.

The BSC, however, does not seem to be a one size fits all application. Kennerley and Neely (2000, cited in Thakkar et al. 2006) note the following regarding the BSC:

- *The absence of a competiveness dimension*

- *Failure to recognise the importance of aspects such as human resources, supplier performance; and*
- *No specification of the dimensions of the performance that determine success*

Luu (et al. 2010) also noted in their research into performance measurement of construction firms in developing countries that the BSC *'is somewhat difficult and time-consuming to implement a comprehensive balanced scorecard in a large organisation'*.

Ng and Skitmore (2014) noted however in their research into developing a subcontractor appraisal system that *"despite the obvious potential benefits of the performance of the balanced scorecard approach, it has not yet been applied to subcontractor appraisal".* Their research and trailing of the proposed subcontractor appraisal system provides insight into the implementation of the BSC system. While their works could correlate to the proposed performance management system of subcontractors, it does have downfall which cannot be ignored. Their subcontractor appraisal system incorporating the BSC is overly complex, and while the need to analytics cannot be ignored in performance assessment, it is quite complicated and in a real world situation, Contract Administrators and Project Managers at the tactical level would struggle to effectively implement this system. Their response rate for industry survey was also low which resulted in a 35% response rate, so the weightings and assessment criteria are questioned. Their scope was limited to large skilled subcontractors within the industry, this is not advantageous as the scope of the proposed performance management system would be to assess subcontractors at all levels and thus would be required to be consistent across all projects. Their system does not appear to be automated as well, which makes implementation overly complex. And as previously stated it is assumed that this system in real time situation would not be effectively implemented.

Authors such as Sommerville and Robertson (2000) and Kagioglou, Cooper and Aouad (2001) have adopted approaches to the BSC using modified scorecards as methods of performance evaluation. These approaches appear to have influences from the BSC works of Kaplan and Norton but have been tweaked to include other factors. Kagioglou, Cooper and Aouad (2001) implemented the BSC to their performance management process framework (PMPF) however; they included additional dimensions to the BSC such as project and supplier perspectives which were seen as missing from the score card. Sommerville and Robertson (2000) used a scorecard approach to benchmarking for total quality in construction and used performance indicators that were identified as important the Morrison group to trail their framework.

Based on the literature research, the BSC appears to be a popular approach to performance evaluation within the construction industry. It does not however appear to be a one size fits all approach to performance evaluation, it appears to be complex in nature and appeal to more of a strategic level of management which, similar to Total Quality Management (TQM) needs to be adopted at all levels of an organisation. In practice, the proposed performance management system will have input and determine the outputs at the tactical and operational levels and be designed to assess all subcontractors. This will require a simple, yet effective evaluation method. A consistent ideology in the literature research is the scorecard approach; wether is based on BSC or a modified scorecard with influence from BSC. A scorecard with a 5 point Likert scale is an effective tool and could provide the information required for the proposed performance management system.

The most important factor to any evaluation method would be the assessment criteria. Table 2.3 provides extensive performance management indicators that could be used in the formulation of the modified scorecard to assess subcontractors and provide the input that will be required for the proposed performance management system.

2.8 Potential frameworks

The proposed performance management system will require some form of framework in order for it to be successfully implemented. The performance management system will need some form of process to it, however, be able to have performance management indicators that are tailored to suit the organisation that implements the performance management system. Literature has been reviewed to identify what has been used previously and what could bear influence on the proposed performance management system framework.

Chan (2009) when measuring performance of the Malaysian construction industry developed a strategy map that outlines success factors that are linked to “strategic thrusts of the master plan” (Chan, 2009). The strategy map is shown in Figure 2.2

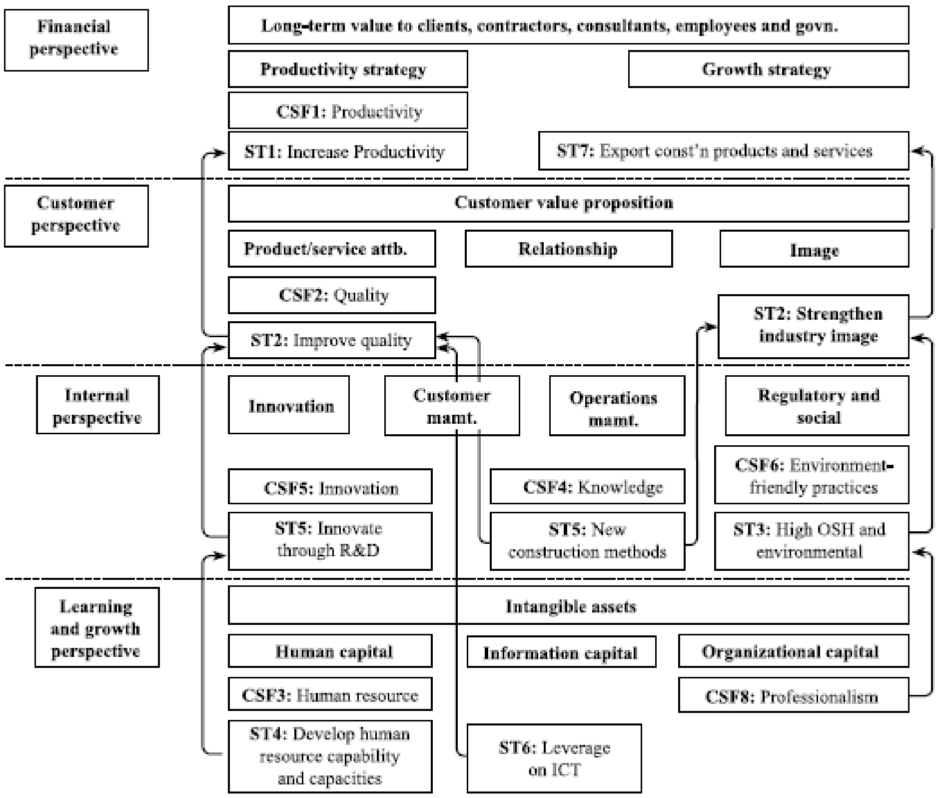


Figure 2.2 Chan’s basic strategy map of critical success factors and strategic thrusts of the Malaysian construction industries master plan (Source: Chan 2009)

The strategy map links the critical success factors with strategies and also divides success factors into the balanced scorecard framework. The strategy map provides a good overview of a system; however, the proposed performance management system will require a process framework that could act as a ‘step by step’ guideline so that it can be used with consistency.

Bassioni et al (2007) when building a conceptual framework for measuring business performance in the construction industry developed a framework visually illustrated as a block diagram as seen in Figure 2.3

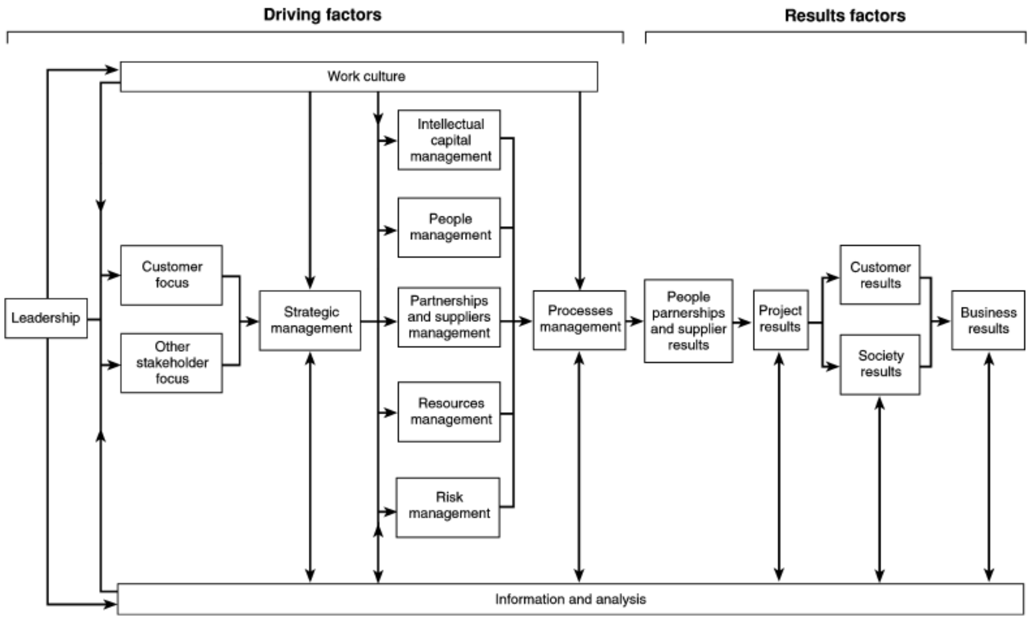


Figure 2.3 Bassioni et al's conceptual framework for measuring business performance in the construction industry visually illustrated as a block diagram (Source: Bassioni et al 2007)

The conceptual framework details driving factors and results factors and identifies a step by step process, correlations between culture and information and analysis that ultimately lead to business results. The block diagram shows a good connection between the steps required in sequence that formula the conceptual framework.

Mbachu, when developing *"a conceptual framework for the assessment of subcontractors' eligibility and performance in the construction industry"* (2008) implemented a process flowchart that provided a step by step guide through the stages of prequalification, pre-contract, construction and close out stages. The process flowchart can be seen in Figure 2.4

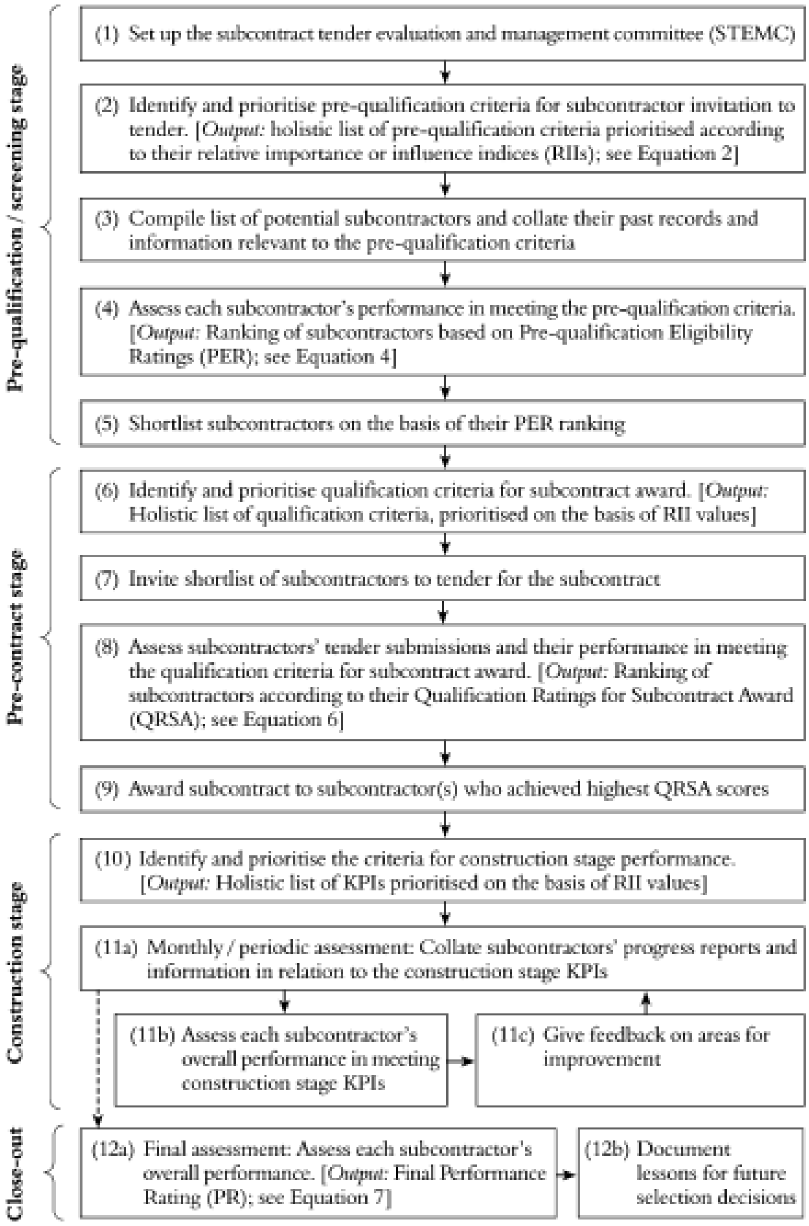


Figure 2.4 Mbachu process flowchart for subcontract selection and management in the construction industry (Source: Mbachu, 2008)

Mbachu process flowchart is a good step by step guideline to his proposed framework for assessment of subcontractor performance. It provides a clear and concise list of steps in sequence that is also staged in the subcontractor contracting process. This provides a good understanding of when the steps are required to be undertaken during the subcontractor sequencing of prequalification, pre-contract, construction and close-out stage.

Based on the literature that has been reviewed, the proposed performance management system would be complemented with a framework that could act as a guideline to the steps involved in successfully implementing the system. A detailed process flowchart would be well suited to the system as it would provide a clear understanding of the sequence of steps involved in implementing the system as well as the stages of the construction at which they would need to be implemented.

2.9 Benefits of a performance management system.

While investigating the benefits of the proposed subcontractor performance management system is outside the scope of this research project, an appreciation of the potential benefits associated with the implementation of such a system should be known. If there were no potential benefits, then there would be no requirement for the proposed system to be implemented.

The purpose of the performance management system is to identify high performing subcontractors based on their previous experience on projects currently undertaken by the principle contractor. This type of quality management system is primarily used to identify high preforming subcontractors. As such, subcontractors who are identified with a higher rating in the database are deemed to be a better performing subcontractor, based on the performance management indicators that are selected by the principle contractor. The SLOTS scheme as mentioned in section 2.3 was also a method of improving subcontractor performance. Loh & Ofori (2000) undertook a detailed investigation into the SLOTS scheme and their studies "found evidence that the introduction of SLOTS registration has directly resulted in improved performance of subcontractors in terms of time, cost and quality". Mbachu's (2007) conceptual framework for the assessment of subcontractors eligibility and performance in the construction industry was also another framework that was designed to improve subcontractor performance, he stated "…that it could contribute to eliminating or minimising subcontracting risk, and could result in improved project delivery". If the proposed subcontractor performance management system is implemented correctly, then there is a strong possibility that parameters of time, cost, and quality could substantially improve as well as reducing subcontracting risk.

Identifying higher performing subcontractors also has the advantage of initiatives that can be introduced such as strategic partnering with subcontractors. This process partners subcontractors with principle contractors for one off or multiple projects. The principle of strategic partnering is the principle contractor and subcontractor work gather more closely than usually in order to achieve the common goal of project success and can have more commercial advantages such as increased profit margins on projects and repeat partnering works on future projects. Strategic partnering also has the benefit of early subcontractor involvement, this allows the subcontractor to become involved in design and construct projects early in the design phase in order to provide advice that can improve design and provide value magament opportunities for the client. Cook and Williams (2013) state with respect to partnering "Perhaps the main contractor should consider adopting a policy of creating good relationships with a small group of reliable subcontractors who business can expand as the main contractor becomes more established. Often the main contractor's reputation may rely solely on the excellence of his subcontractors' performance". If the principle contractor was to implement, the proposed performance management system, then they could start to identify high performing subcontractors that could be interested in long term strategic partnering which would be an advantageous relationship to both parties.

Another option that could be utilised with the implementation of the proposed subcontractor performance management system is the pairing of monetary retentions to subcontractor's performance. According to Abeysekera (2015) "contractors do not appear to differentiate between good subcontractors and bad subcontractors; all are treated alike when it comes to retention regimes. Moreover, it is not uncommon for subcontractors to have multiple contracts with the same contractor on different projects with all contracts subject to similar retentions regimes. This would mean that a contractor would hold a large sum of money at a given point of time sometimes as much as the value of single contract". If higher performing subcontractors were identified by the performance management system, then these subcontractors could be rewarded with reduced retention that is held within the typical construction subcontract agreement. This also could motivate the subcontractor to produce a higher quality job in order to obtain such a status with certain principle contractors.

According to Creed et al (2008), *"Most studies have related to subcontracting have focused on issues related to improving the overall process or selecting of subcontractor. Almost no studies have developed strategies for subcontractor management or for maintaining long-term relationships, or have conducted practical research on continuous evaluation and feedback within this framework".* This was the basis of Creed et al (2008) to undertake the study of subcontractor evaluation and feedback model that would drive improvement of the subcontractor. As the feedback model is helpful in guiding future decisions of the principle contractor, it is also helpful if this feedback of subcontractor evaluation would be shared with the subcontractor so that they can review their performance from a principle contractor's perspective. This feedback could potentially "enable them [subcontractors] to identify areas for concentration and improvement, and their efforts to improve will result in mutual growth, benefiting both the main contractor and the subcontractor" (Creed et al 2008).

Creed et al (2008) also advocated the use of a modified scorecard as a template for assessing subcontractor performance. This would be a good format for the subcontractor assessments post construction that need to be undertaken to gather the data for the performance management system input.

This process of subcontractor feedback of assessment could be incorporated into the performance management system framework as a step to provide subcontractors feedback once the evaluations are done on their performance post construction. If this step is incorporated into the process flowchart that is used to model the subcontractor performance management system, the subcontractors could see immediate benefit of the system, allowing them to review and reflect of their assessment on the recently completed project. This could allow the subcontractor to make immediate adjustments to their performance which will contribute to overall continuous improvement for the subcontractor's organisation and could work to strengthen the relationship between the principle contractor and the subcontractor.

2.10 Development of a performance management system

After an extensive literature review, key factors have been identified that will have a significant influence on the proposed subcontractor performance management system. These key factors have been identified, analysed and interpreted throughout this literature review, successful implementation of these key factors will be paramount to establishing the relevance of the proposed performance management system. These key factors will be reviewed in this section.

Section 2.2 provided information on the need for a performance management system. This is an important first step for any type of quality initiative, or performance management system as an organisation needs to realise the need to implement such a system based on their understanding for the requirement. Organisation's who wish to implement such a system need a total commitment from all levels of management in order for successful implementation, this is similar to the Total Quality Management (TQM) model (Evans and Lindsay, 2014) where an organisation as a whole needs to commit to the TQM system in order for effective implementation.

Section 2.4 identified performance management indicators and their importance for the proposed subcontractor performance management system. The list of performance management indicators in Table 2.3 will form the list of assessment criteria that can be tailored to suit the individual needs of the organisation. The performance management indicators as noted in section 2.4 will be specific to the individual needs of the organisation that chooses to implement the performance management system. The performance management indicators identified in Table 2.3 can be used to select the key criteria that the organisation deems necessary to use to assess subcontractors and forms a fundamental part of the proposed performance management system.

All subcontractors that operate within Australia are required to be appropriately licenced. Section 2.5 provided an extensive literature review of the requirements of the QBCC to issue subcontractors licences to perform building work. If a subcontractor holds QBCC licence for a particular trade discipline, it will not be a replacement for a performance management system, however, a QBCC licence search will identify if the subcontractor has the relevant experience, managerial skill, technical qualification and financial requirements to at a minimum, be entitled to tender on a project. As such, the proposed subcontractor performance management system will have a minimum requirement for subcontractors to be appropriately licenced before being entered into a database that will provide principle contractors with a list of potential subcontractors who will be able to perform work.

Section 2.6 provided an understanding of data analysis in subcontractor performance management to determine if past performance could be an indicator of future performance. An article on the subject was found by Cheng (2014) on the topic. Chengs work identified a concept called the Risk Possibility Assessment (RPA) Method which used basic data analysis to provide an indication of future performance and a risk profile based on standard deviation of past performance. This will be a key factor to the proposed subcontractor performance management system.

Section 2.7 identified that a score card approach to subcontractor evaluation would be the best fit for the proposed subcontractor performance management system. The score card would consist of the selected performance management indicators identified from Table 2.3 and be tailored to suit the individual needs of the principle contractor's organisation. This scorecard would be used for all subcontractors on a project and provide the evaluation criteria that is used to assess subcontractors performance. The information obtained from the scorecard assessments would act as the primary inputs into the proposed performance management system and as such is an integral piece of the performance management system.

The performance management system will also require a guideline that can be used as a step by step process so that the performance management system can be utilised by any form of principle contractor. As such, section 2.8 identified a detailed process flowchart as a means to provide this to organisations. A detailed process flowchart would be well suited to the system as it would provide a clear understanding of the sequence of steps involved in implementing the system as well as the stages of the construction at which they would need to be implemented.

Finally, an appreciation of the benefits of a performance management system should be known. There needs to be an output from the implementation of such a system and the benefits of a system need to be known. Section 2.9 identifies improved that quality subcontracts can be found using the performance management system and as such can increase aspects of time, cost and quality as well as reducing the risk of subcontractor performance. Commercial endeavours such as strategic partnering could also be an option for high performing subcontractors that are identified by the system; this has numerous benefits to both the principle contract and the subcontractor. Finally, the concept of matching monetary retentions that are held in accordance with the level of performance of the subcontractor is also proposed, using this method, higher performing subcontractors may be subject to less retention held on subcontracts.

Chapter 3: Methodology

3.1 Overview

In order to successfully investigate the creation of a functional performance management system for principle contractors to assess subcontractors, a methodology needed to be developed in order to provide a process at which this could be achieved. The process needed to be streamlined and easy to follow and needed to ensure that all aspects of the project specification were fulfilled. The following sections outline the methodology in how the three subsections of the specification were met.

3.2 Literature review methodology

Subsection A of the project specification states that relevant literature for the design of a performance management system needed to be understood. To achieve this objective, an extensive literature review needed to be undertaken. There is no limit to the amount of articles that needed to be reviewed; this was only limited to the relevance and validity of the information in order to successfully understand the requirements of the proposed subcontractor performance management system. A suitable strategy for the literature review was required to be developed in order for the literature to be effective within the research project.

Articles were searched in the categories of construction performance management, subcontractor performance management and construction evaluation methods etc. These articles found were peer reviewed journal articles for authenticity. Some textbook resources were used depending on the relevance, however the findings in these text books were subsequently authenticated by relevant peer reviewed literature. The summaries and abstracts of the articles were read first to identify whether the articles were valid. Once the article were selected as an article that was worth further reading they were then indexed in order of the 9 categories listed below:

1. Identify need for a subcontractor performance management system
2. Identify what is performance management, specifically performance management within the construction industry
3. Investigate what are performance management indicators.

4. Research how subcontractors and builders respectively are licenced within Australia to determine if there is any relevance to a subcontractor performance management system.
5. Research performance management criteria to determine key factors that will influence the development of the subcontract performance management system.
6. Evaluate whether subcontract past performance can be an indicator of future performance.
7. Explore the different types of performance management evaluation methods and determine the most appropriate method to utilise within the performance management system.
8. Understand potential frameworks to be used for the development of the performance management system.
9. Explore the benefits of a subcontractor performance management system.

Articles that were then indexed as having literature reviews conducted. The literature review provided the insight into the background of the topic of subcontractor performance management. All articles were then entered into Endnote software for future reference. The articles were then used to provide an overview of the nine sections listed in the above. The literature review forms a major part of the research project and articles needed to be fully understood in order to determine their relevance to the overall aim of the research project. The results of this literature review are found in chapter 2 of this report and are referenced in Harvard APGS format as required. A guideline was then created based on the findings of the literature review.

3.3 Guideline for a performance management system

Subsection B of the specification states that a guideline for the performance management system needs to be developed. This required identification of suitable frameworks and a selection of the most suitable framework as well as establishing its relevance within the industry. The aim of this guideline was to implement a 'one size fits all' template for construction organisations to implement to their existing management systems. This guideline serves two purposes, firstly to develop a guideline that was used as a format for the case study in chapter 4, but secondly to be used as the template at which a contracting organisation can implement them.

Section 2.8 reviewed a number of different frameworks that could potentially be used for the performance management system. Based on the application of the template style framework that can be integrated into existing systems, the process flowchart was selected as the most suitable format for the performance management system. The detailed process flowchart whilst modified is conceptual in nature and provides the right information in a step by step format so that it is easily understood and can be modified at will. This is a mandatory requirement, as PMIs need to be selected for the subcontractor evaluations through a series of surveys. This provides the performance management system with a customised approach and allows contractors to select their PMIs for subcontractor assessment based on their organisations perception of suitable PMIs. The conceptual process flowchart is an 11 step process and is presented in figure 3.1.

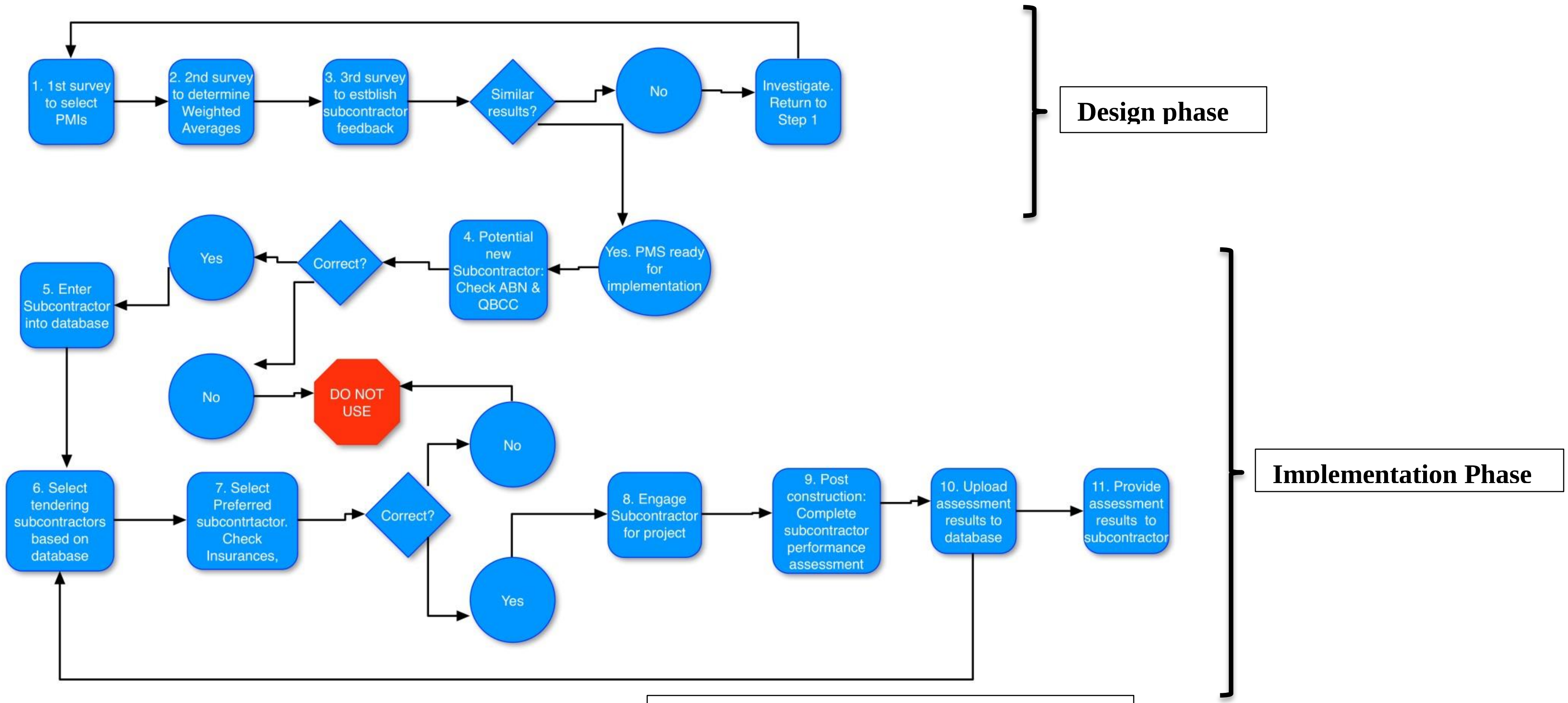


Figure 3.1 Concepual Process Flowhart

PMI – Performance Management Indicator

PMS – Performance Management System

ABN – Australian Business Number

QBCC – Queensland Building Construction Commission

The conceptual process flowchart is an 11 step process which also includes some hold points for decisions which are easily made during the procurement process of subcontractors for a construction project. The conceptual process flowchart can be divided into two phases, the design phase of the system and the implementation phase. These steps are explained further below. The steps of the process flowchart are identified by the square activities, the diamonds represent decisions or hold points at which point an informed decision is to be made regarding a particular subcontractor and the circles represent the decision which affects the concurrent activity.

3.3.1 Design Phase – Step one

Section 2.3 highlighted the need for PMIs to be tailored to suit the organisation due to variances in organisational culture, values, goals and size. As such, the first steps in the conceptual process flowchart are concerned with the design of the performance management system with respect to the organisational specific PMIs required for the system to then become implemented and operational. Step one is the first step to implementing the subcontractor performance management system and involves a survey by relevant construction personnel within a principle contractor's organisation. This is the first of three surveys, the aim of which is to select the top ten subcontractor PMIs relative to the contractors organisation. The selection of these performance management indicators can be from the table 2.3. There is a total of 51 PMIs available for selection by the principle contractor. A template for this survey has been produced and is featured in Appendix C. the construction personnel who under take this survey can be selected by the principle contractor who chooses to implement the system, however it is recommended that senior management undertake the survey with a minimum of 15 years' experience within the construction industry. For feedback from the 'coal face' of the projects it is also recommended that senior management personnel select key employees from site and office background who have minimum of 10 years' experience. This will provide a good coverage for selection of the PMIs within the organisation.

Section 2.7 identified that the modified scorecard approach was the most useful approach to performance evaluation. By using a 5 point Likert scale the survey participants can easily tick the relevant rank of each of the 51 surveyed PMIs. Once these surveys have been undertaken, the Relative Important Index (RII) formula can be used to identify the top ten PMIs. The literature review identified a various number of indicators used for assessment. As the 51 identified factors could not be ignored they need to be reduced down to a workable number of suitable indicators and ten appears to provide a good spread of performance indicators. The RII is a simple statistical analysis calculation that defines performance management indicators relative importance in proportion to each other, as some performance management indicators may have a higher importance than others in the opinion of the contractor who is implementing the proposed performance management system. This will identify the main performance management indicators important to the contractor's organisation.

3.3.2 Design Phase – Step two

Once step one has been completed then the top ten PMIs would have been identified. Step two involves a second round of surveying of the organisations key personnel who undertook the first round survey in order to provide weightings to the top 10 PMIs. Some PMIs may have higher weighing's according to the organisations personnel and any evaluation assessment of subcontractors should be adjusted to suit these weighted averages accordingly. Again, a 5 point Likert scale is used to rank the top ten PMIs; the template formatted for this survey is featured in Appendix D. Once the survey results have been received, further data analysis is required. The relative weighting will then be calculated for each of the ten PMIs and be used as the basis for the subcontractor performance evaluation. At this point it will be rational to obtain subcontractor feedback on the selected PMIs and their weightings. This is to ensure that there is no gap between the way that subcontractors are assessed by the contractor and the subcontractor's perception in how they will be evaluated.

3.3.3 Design Phase – Step three

Step three in the conceptual process flowchart is to obtain the feedback on the top ten PMIs from subcontractors. Subcontractors will be asked to complete the round three survey as featured in appendix E. This is again a 5 point Likert scale which can be used for relative weighting assessment. The number of subcontractors to obtain feedback can be determined by the contractor; however as a baseline 5 of the more common trades on project could be selected to complete the survey. This survey should also be used to obtain some verbal feedback from subcontractors to provide feedback that the survey may not be able to. If there is major discrepancy in the subcontractors results compared to the contractors results with respect to the top ten selected PMIs and their respective weightings, then it is advised that the contractor should revert back to step one to revaluate their selected PMIs. A gap in performance evaluation between the contractor and subcontractors may lead to disputes in the future so it is important that both parties' visions align with respect to performance evaluation.

3.3.4 Implementation Phase – Step four

Once the design phase has been completed, the PMIs are selected and weighted and ready for implantation. Step four has been inserted into the process flowchart and is done on an as required basis. It is a quality assurance step of checking that each new subcontractor who is proposed to be entered into an organisations subcontractor database is checked appropriately for current Australian Business Number (ABN) and QBCC licence numbers as well as citing updated subcontractors works insurance. The purpose of the ABN check is ensure that the proposed subcontractor can legally be entitled to enter into a subcontractor agreement and the QBCC licence numbers ensure that subcontractors are suitably 'prequalified' to undertake work relating to their disciplines. Organisations that have an existing database should check that all subcontractors in the database have current ABN and QBCC numbers. The first decision step in the flowchart involves this process of checking the current ABN and QBCC information is valid. Existing or potential subcontractors who at a minimum do not have current ABN or QBCC numbers should not be proposed to be used until this can be rectified. If the information is not current, then the contractor should not be entered into a subcontractor database for future use.

If the information is current and valid, then the contractor can proceed to step five.

3.3.5 Implementation Phase – Step five

Step five is inserted to the process flowchart for new contractors if they quality to be entered into the principle contractors database, that is, if their QBCC, ABN and subcontractors insurances are current. This allows subcontractors at a minimum to be invited to tender once they are entered into the subcontractor database. Their selection to tender would be based on database statistics that are used from previous projects. Initial subcontractors would not have a score based on the RPA method of subcontractor performance management as identified in section 2.6, however, the base of a current ABN, QBCC numbers and updated insurance certificates is a form of 'prequalification' that all tenderers that price a tender can undertake the works if the tender is successful. Note that if the subcontractors are already registered the contractor's database system, then steps four and five can be skipped and the contractor then can move to step six.

3.3.6 Implementation Phase – Step six

Step six is the invitation for subcontractors to tender on upcoming projects, this selection of subcontractors will be based on the data analysis provided by the RPA method. The RPA method will be discussed further in step nine. Successful subcontractors will receive a higher confidence interval (score) and can easily be identified. Section 2.9 of the literature review identified various benefits of the performance management system and by using higher performing subcontractors to tender on construction projects will effectively mean a better quality project as an end result. Section 2.9 also identified that if higher performing subcontractors are selected at tender stage, this could effectively reduce the tender period by identifying the higher performing subcontractors up front. Subcontractor and principle contractor partnering is also an option at this stage, as long as the information from data analysis is input to the principle contractors database, this information can be easily extracted to identify quality subcontractors.

3.3.7 Implementation Phase – Step seven

Once the tender period has closed, subcontractor tender proposals would be reviewed and assessed, step seven is the selection of the preferred subcontractor and is also another quality assurance step for ensuring that prior to subcontractor engagement, that the subcontractor has a current ABN, QBCC number current works insurances as per section 2.6 of the literature review. While this may look like a repeated stage of step four, it is a necessary step. This is because ABN and QBCC numbers like most licences have expiration dates or can be superseded, modified or suspended at will. An existing subcontractor may not have been used for a certain period and may have a lapsed QBCC number.

Section 2.5 of the literature review identified the licencing requirements in order for subcontractors to enter into a contract with principle contractors. Step seven also will need to review the Annual Allowable Turn Over (AATO) to check the subcontractor has not exceeded this in the current financial year. Subcontractors are allowed to turn over a certain amount of money pending on their Net Tangible Assets (NTA). For example, a high performing concrete subcontractor may be selected for engagement for a large high rise building project after not being used in the previous 12 months by the principle contractor. During this time the subcontractor may have liquidated some assets. The principle contractor proposed to engage the subcontractor on a contracted value of $4m, however a QBCC licence check may reveal that the subcontractors AATO is now capped at $3m for a financial year. This represents the importance of step seven as under the QBCC; the concrete subcontractor is not allowed to undertake a project of this size as it exceeds his current AATO. The subcontractor should not be engaged until this is rectified with QBCC or they should not be permitted to be used for the project as it poses a significant commercial risk to the principle subcontractor.

3.3.8 Implementation Phase – Step eight

If the subcontractor is eligible to pass the step seven hold points, then the subcontractor can be engaged at step eight. This engagement could be any form of subcontractor agreement and subcontractor performance management system does not provide any preference to the type of subcontractor that could be used.

3.3.9 Implementation Phase – Step nine

Step nine is undertaken at the completion of the construction project. The subcontractor evaluation of the recently completed construction project is the crux of the performance management system. This performance evaluation will take form of a an assessment of the performance based on the previously selected ten PMIs from step two and per section 2.7 of the literature review, a 5 point Likert scale will be used as a basis for assessment. Appendix F features the template model that can be used for the subcontractor performance evaluation. At practical completion, a member of the project team will undertake the subcontractor assessments. This should be undertaken for all subcontractors and should be undertaken with an honest evaluation of the subcontractor's performance on the completed project as this will affect the subcontractors rating with the principle contractor's organisation and a bad review could affect the subcontractor's ability to undertake future works with the subcontractor.

Once the performance evaluations are completed for each subcontractor by the contractor, the RPA method can then be used to analyse the performance of the subcontractor. Using equations applicable to the RPA method as identified in section 2.6 of the literature review, the expected value (mean), standard deviation, coefficient of variation and subsequent confidence interval can be calculated to project the future performance.

3.3.10 Implementation Phase – Step ten

Step ten involves inputting the results from step nine into the database for future use and analysis for the use of coming projects. This database would record the results of the evaluations and then use this information in the RPA method proposed in chapter 2 to assist in predicting future performance of subcontractors. The database would need to be structured in such a way that information could be input for various project evaluations if required. It should be noted that format and layout of the database is not covered in this research project as this is deemed as a contractor specific document and is subject to the principle contractors Information Technology

(IT).These results can then be used for future projects and will be reviewed for upcoming projects again at step six of the conceptual process flowchart.

3.3.11 Implementation Phase – Step eleven

Finally, step eleven can also be undertaken and involves providing feedback from the subcontractor evaluation to the subcontractor. Creed et al (2008) established the importance of subcontractor feedback via their subcontractor evaluation feedback model as identified in section 2.9 of the literature review. This process is an important step in the process flowchart as it provides the subcontractor an opportunity to review its performance on the recently completed project from the perspective of the principle contractor and can allow the subcontractor to improve on future projects or make adjustments as necessary.

3.4 Establish the performance management system's relevance

Subsection C of the specification states that it required the performance management system to be tested to understand its relevance within the construction industry. This was done through the undertaking of a case study using the performance management system and a subsequent discussion of the results. The best type of testing for the application of the performance management system. According to UNSW (2015), "A case study is an account of an activity, event or problem that contains a real or hypothetical situation and includes the complexities you would encounter in the workplace. Case studies are used to help you see how the complexities of real life influence decisions". A case study in this situation allowed the performance management system to be tested within a real world application and allow appropriate analysis to be performed in order to establish relevance within the construction industry, further refinement and further work required. It should be noted however that this case study wasn't run in real time application, as subcontractor evaluations post construction could take years to gather multiple performance evaluations in order to establish a baseline of performance. This will be explained further in the following sections. It has however followed the conceptual process flowchart for subcontractor assessment as presented in section 3.3 through the design stage and parts of the implementation stage. The case study was undertaken in conjunction with a principle contractor's organisation that consented to participate in the case study. For privacy reasons the principle contractor has been referred as 'the contractor' within the case study. Subcontractors will be referred to as 'subcontractor 1, subcontractor 2 etc.'

3.4.1 Design Phase – Step one

Step one of the case studies, was to undertake the first round of surveys of the contractors authorised representatives. Section 3.3 identified that senior management of at least 15 years within the construction industry be selected to undertake the surveys to be surveyed on the 51 PMIS as identified in section 2.3. The contractor selected 3 senior managers as identified in the previous section, these senior managers then selected at will several employees throughout the organisation to also participate, as a prerequisite for participating in the case study, these selected employees that work in the 'coal face' of the industry had at least 10 years' experience. Senior managers selected an additional 10 employees which brought the total number of contractor's survey participants to 13. All employees that participated in the case study were required at this stage to give their consent to participate by completing a consent form which is signed by the author and the participant. This template consent form is featured in appendix G. Once surveys were undertaken the data needed to be analysed and rank the 51 PMIs in the relative important index (RII) and the top ten PMIs were then able to be selected.

3.4.2 Design Phase – Step two

Step two involved the same survey participants and used the template in Appendix D to distribute the round two surveys of the top ten selected PMIs. Once this feedback was received, the data was analysed and the relative weightings of each of the ten PMIs were provided. This provided the top 10 ranked and weighted PMIs as chosen by the contractor.

3.4.3 Design Phase – Step three

Step three involved the feedback from the subcontractors. Subcontractors from five popular trade fields were approached to participate in the case study. The subcontractor participants were required to complete the survey consent form as featured in Appendix H. Using the subcontractor survey template as featured in appendix E, the subcontractors were required to complete the form and provide some general feedback regarding the performance management indicators that have been selected by the contractors for performance evaluation. Subsequent data analysis was undertaken to correlate the results between the subcontractors and contractors, also taking into account the comments received by the subcontractors on the PMIs selected.

3.4.4 Implementation Phase – Steps four to nine

The case study was not be able to run in a real time application, so in order to gather sufficient data for the case study, two subcontractors were selected from the same trade area for performance evaluation throughout the case study, this enabled the predictive model being the RPA method as identified in the literature review, to be tested and enabling a comparison between two subcontractors in a similar field. As such certain steps of the implementation phase were not required to be undertaken. Step four and step five in the process flowchart will not be required as the subcontractors will be subcontractors that will be known to the contractor and will not be required to be set up into the contractors' database.

Again, step six will not be able to be implemented into the case study, as the two subcontractors that will be selected for comparison will have already completed a number of jobs that will be used for subcontractor performance evaluation. Step six is the invitation for subcontractors to tender based on previous performance, while this is not able to be done, after the subcontractor evaluations using the RPA method in step nine, recommendations can be made on future engagement based on the RPA method of data analysis. Step seven is the selection of preferred contractor with QA checks to ensure that current insurances, ABN, QBCC numbers and insurances are current prior to any contract agreement being executed. Again, this will not be valid for this case study and the subcontractors would have already been engaged previously for the project. A spot check of the certificates of currency and current QBCC and ABN numbers can be undertaken however this will only provide authentication of the subcontractors' qualifications after the fact. Nonetheless this can be checked in the case study. Step eight in the subcontractor engagement process and is not required given the time constraints for the case study as mentioned above.

3.4.5 Implementation Phase – Steps nine

A strong focus in the case study was step nine. This step involved the subcontractor performance evaluation using the RPA method as discussed in section 3.3. Using the historical data from at least five recently completed projects, two subcontractors were selected by the contractor for performance evaluation against the contractors ten selected and weighted PMIs using the template featured in appendix F. These results were then collated and analysed with the application of the RPA method. This established expected values for future performance and an associated risk profile of the subcontractors. This information is then used as a basis for predicting the future performance of the subcontractors with a subsequent risk profile.

3.4.5 Implementation Phase – Step ten

Step ten is to input these results to an organisations database and use this information on future projects at step six for subcontractor selection. As this system is not yet implemented within the contractors' organisation the results will be provided to the contractor for review. This provides an appreciation for the system and its functions.

3.4.6 Implementation Phase – Step eleven

Step eleven involves subcontractor feedback, given the confidential nature of the case study, the results were provided to the contractor only. It is then be at their discretion wether this feedback information is provided to the subcontractors. As this is only a testing of the performance management system and is not currently implemented with the contractor, consideration has been given to not compromise the contractors' relationships with test statistics from this case study.

3.4.7 Case study discussion and further refinement

As the case study has been completed, a discussion of the results and observations has been made. The case study has identified some further refinements to the system which can be incorporated as part of future work.

3.5 Safety Issues

The research project involves no physical activity and such work will be limited to desk work within an office environment. A risk assessment has been undertaken for the desk work and is shown in Table 3.1

Hazard	Liklihood	Exposure	Consequence	Effected	Control Measures
Back Pain	Slight	Rarely	Minor Repitive Strain Injury	Self	Routine breaks and quality seat with appropriate padding and support
Wrist Pain	Slight	Rarely	Minor Repitive Strain Injury	Self	Routine breaks and ergonomic type keyboard for wrist comfort
Neck Pain	Slight	Rarely	Minor Repitive Strain Injury	Self	Routine breaks, streching and quality seat with appropriate padding and support
Leg Pain	Slight	Rarely	Minor Repitive Strain Injury	Self	Routine breaks, streching and quality seat with appropriate padding and support. Use of foot stool for support
Eye Strain	Significant	Rarely	Minor Headaches and eye soreness	Self	Routine breaks, ensure adequate lighting for desk work
Stress	Significant	Occasionally	Headaches, Anxiety	Self	Routine breaks, adequate rest and relaxation between work sessions

Table 3.1 Risk Assessment

3.6 Resource requirements

As the research project is largely theory based, the work is primarily done within an office environment and as such equipment and facilities required are readily available. Table 3.2 lists the resources required for the project

Resource	Availability	Cost	Importance	Alternative Available
Laptop	Permanent	$0	Significant	Yes
Microsoft Word	Permanent	$0	Significant	Yes
Microsoft Outlook	Permanent	$0	Significant	Yes
Microsoft Powerpoint	Permanent	$0	Significant	Yes
Microsoft Excel	Permanent	$0	Significant	Yes
Internet Explorer	Permanent	$0	Significant	Yes
Endnote	Permanent	$0	Significant	Yes
Laser Printer	Readily available	$0	Significant	Yes

Table 3.2 Resource Requirements

Chapter 4: Case study

4.1 Introduction

In order to prove the subcontractor performance management system's relevance within the construction industry, it is necessary to test the proposed system in a practical application. This chapter seeks to apply the theory behind the proposed subcontractor performance management system, seeking input from relevant construction industry personnel. The methodology of this case study will be consistent with what has been presented in section 3.4. Given that subcontractor performance evaluations are done at the completed of construction projects, the comparison of subcontractors for evaluation will be based on recently completed projects and as such, some steps in the conceptual process flowchart will not be required. The case study will largely deal with industry survey, selection of PMIs, subcontractor feedback and a range of data analysis. A discussion of the results will also be undertaken, as it is anticipated that the case study will highlight positives from the performance management system, but also any shortfalls within the system that can be refined and recommended for future work.

4.2 Application of the case study

The contractor selected to undertake the case study is a mid-tier privately owned construction company with an annual turnover in excess of 1.365 billion dollars. The contractor has a network of over 10,000 subcontractors and operates throughout Australia and New Zealand however does not have a formalised system's approach to subcontractor procurement. The contractor was selected to participate in the case study based on the strong contractor/subcontractor relationship throughout the organisation.

Subcontractor 1 and subcontractor 2 whom will be used as a basis of performance evaluation within the case study are electrical subcontractors within the Commerical construction sector and are similarly staffed with previous track records of a number of recently completed projects. Their selection to be evaluated within the case study is due to the metadata for performance evaluation being readily available from the contractor, given the period available to undertake the case study.

4.2.1 Design Phase - Step one

The round one survey involved thirteen staff from the contractors' organisation. Minimum requirement for staff to undertake the case study surveys was that senior management required a minimum of 15 years' experience in the construction industry, and the senior managers randomly selected staff members to participate with a minimum of 10 years in the construction industry. A summary of the participants is listed in table 4.1 below.

Position	**Participants**
Construction Manager	2
Procurement Manager	1
Design Manager	1
Project Manager	2
Estimator	2
Site Manager	4
Contracts Administrator	1
Total	**13**

Table 4.1 Participant and position summary of the contractors' participants

Based on the participants of the contractors' organisation, the average age of the participants was 39 who had an average of 18 years in the construction industry. This provides a good spread of experience throughout the organisations participants.

The thirteen respondents were presented with the first round survey listing the PMIs that were identified in the literature research as relevant indicators for subcontractor performance. The 51 PMIs were scored on a 5 point Likert scale (see Appendix C). A Relative Importance Index (RII) calculation was used to determine the top ten PMIs that the contractors respondents felt were the top ten most significant PMIs. The RII equation provides the relative importance based on the scales of the answers and is often associated with Likert scale surveys and is shown in equation 4.1 below.

$$RII = \frac{\sum W}{AN}$$

Where

W = weighting given to each factor ranging from 1 to 5

A = higher weight on the Likert scale

N = total number of answers

Equation 4.1 Relative Importance Index (RII) Equation

The results of the round one survey are listed in table 4.2 below.

	Performance Management Indicators	Survey Results													Average	RII
1	Design Ability	5	2	1	3	4	2	4	5	4	5	3	4	4	3.538	0.7077
2	Level of Understanding of Scope	5	5	5	5	5	4	4	4	3	4	3	5	5	4.385	0.8769
3	Value Engineering Thoughts	5	3	4	3	5	2	3	5	4	4	3	4	3	3.692	0.7385
4	Response to Construction Feedback	4	4	4	3	4	4	2	4	3	3	3	4	4	3.538	0.7077
5	Reaction to 'Realistic Costs'	5	4	4	4	4	4	2	3	3	4	3	4	4	3.692	0.7385
6	Quality Awareness	5	5	5	5	4	5	3	4	3	4	3	5	3	4.154	0.8308
7	Previous Experience as subcontractor	4	5	4	4	5	4	4	4	3	3	4	5	4	4.077	0.8154
8	Communication	4	4	4	4	5	5	4	5	3	4	4	5	4	4.231	0.8462
9	Financial Capacity	5	5	4	4	5	4	4	5	3	4	3	4	5	4.231	0.8462
10	Technical Capability	5	5	4	5	4	4	4	5	3	4	3	5	4	4.231	0.8462
11	Reputation	4	4	5	4	4	4	3	4	4	3	4	5	5	4.077	0.8154
12	Subcontractors workload	5	5	5	4	4	3	1	4	4	4	3	5	5	4.000	0.8000
13	Clients Acceptance of Subcontractor	5	5	5	4	5	4	3	4	4	4	3	4	4	4.154	0.8308
14	Tender Price	4	5	5	4	4	5	3	4	4	4	3	4	5	4.154	0.8308
15	Quality	5	5	4	5	5	5	4	4	3	5	3	4	5	4.385	0.8769
16	Subcontractor References	3	4	5	3	3	5	1	4	4	4	3	5	4	3.692	0.7385
17	Geographical Location	3	3	3	3	3	3	1	3	3	3	3	3	4	2.923	0.5846
18	Safety	5	4	4	4	4	5	2	5	2	4	4	4	5	4.000	0.8000
19	Meeting Attendance	5	3	5	4	3	5	2	4	4	3	4	5	3	3.846	0.7692
20	Adherence to Construction Program	5	5	5	4	4	5	4	5	3	4	3	5	5	4.385	0.8769
21	Honesty and Reliability	5	5	5	5	4	5	4	5	3	4	4	5	5	4.538	0.9077
22	Previous Experience with main contractor	4	4	4	4	4	4	3	3	4	3	4	5	3	3.769	0.7538
23	Construction Methodology for site work	5	4	5	4	5	4	4	4	4	4	3	4	4	4.154	0.8308
24	Cooperativeness with main contractor	5	4	5	5	5	4	3	4	3	4	4	4	5	4.231	0.8462
25	Material Wastage on site	4	3	5	3	3	3	3	4	2	4	3	5	4	3.538	0.7077
26	Defects Liability Servicing	5	5	5	4	4	4	4	4	2	4	3	5	5	4.154	0.8308
27	Collaboration with other Subcontractors	4	4	5	4	4	4	2	4	3	3	3	5	5	3.846	0.7692
28	Workspace Cleanliness	5	3	5	4	3	5	3	4	2	4	3	4	5	3.846	0.7692
29	Management Ability	5	3	5	4	4	5	2	4	3	4	3	4	4	3.846	0.7692
30	Environmental Impact	4	3	3	3	3	4	2	4	2	4	3	4	4	3.308	0.6615
31	Variation Claims	4	4	5	4	3	4	3	3	4	5	3	4	4	3.846	0.7692
32	Resource Control (Material, plant, equipment etc)	4	3	4	4	3	4	2	4	4	4	4	4	5	3.769	0.7538
33	Contractual Risk (BCIPA & Construction claims etc)	5	4	4	3	4	4	2	5	4	5	3	4	4	3.923	0.7846
34	Training and Development of Employees	3	2	3	3	3	5	2	4	4	4	3	5	4	3.462	0.6923
35	Employee Satisfaction and involvement	4	2	4	3	3	5	3	4	4	3	3	4	4	3.538	0.7077
36	Flexibility in critical activities	5	4	5	3	4	5	3	4	3	4	3	4	5	4.000	0.8000
37	Flexibility in non-critical activities	4	3	4	3	4	5	3	4	4	4	3	4	5	3.846	0.7692
38	Post contract attitude	5	4	5	3	4	3	2	4	3	4	4	4	5	3.846	0.7692
39	Willingness to tender	5	4	5	4	4	3	3	4	3	3	4	5	4	3.923	0.7846
40	Knowledge of construction regulations	4	4	5	3	4	3	3	4	2	5	3	4	5	3.769	0.7538
41	Failure in timely progress claims	4	3	4	3	4	3	2	4	3	4	3	5	4	3.538	0.7077
42	Past records on conflicts and disputes	4	3	5	3	4	4	2	3	3	3	3	5	4	3.538	0.7077
43	Successful past projects	5	4	5	4	4	4	4	4	5	4	3	5	4	4.231	0.8462
44	Employee turnover	4	3	5	4	3	2	3	3	3	3	3	5	3	3.385	0.6769
45	Union knowledge and relationship	3	4	3	3	3	4	3	3	4	4	3	4	3	3.385	0.6769
46	Current workload commitment	5	5	4	4	4	5	2	4	4	4	3	4	5	4.077	0.8154
47	Cost Deviation from tender pricing	5	5	5	4	4	2	3	4	3	5	3	5	5	4.077	0.8154
48	Deviation of construction practical completion date	4	5	4	4	4	2	2	3	4	5	3	4	5	3.769	0.7538
49	Efficiency of direct labour	3	4	4	4	4	4	3	4	4	4	3	4	4	3.769	0.7538
50	Effectiveness of works planning	5	3	5	4	4	4	3	4	4	4	3	4	5	4.000	0.8000
51	Commitment Reliability (e.g. Keeping their word)	5	5	5	4	5	4	3	5	3	5	3	5	5	4.385	0.8769

Table 4.2 Summary of the round one survey results

From the 51 PMIs listed for analysis, the top ten were selected based on the RII rankings and are listed in table 4.3.

Rank	No	Name	RII
1	21	Honesty and Reliability	0.9077
2	51	Commitment Reliability (e.g. Keeping their word)	0.8769
3	15	Quality	0.8769
4	20	Adherence to Construction Program	0.8769
5	2	Level of Understanding of Scope	0.8769
6	24	Cooperativeness with main contractor	0.8462
7	43	Successful past projects	0.8462
8	8	Communication	0.8462
9	9	Financial Capacity	0.8462
10	10	Technical Capability	0.8462

Table 4.3 Summary of top ten PMIs as selected by the contractor's respondents

It can be seen that the highest ranked PMI is Honesty and reliability which is ranked well above the second placed PMIs of commitment reliability, quality, adherence to construction program and level of understanding of scope. Tied third is cooperativeness with main contractor, successful past projects communication, financial capacity and technical capacity. It is interesting to note that elements relating to subcontractors price or safety were identified within the top ten selected PMIs. Subcontractors' tender price had an RII of 0.8308 which was a higher score but not in the top ten and safety had an RII of 0.8000 which was in the mid-range for PMI ranking.

4.2.2 Design Phase - Step two

Step two in the process flowchart is the round two surveys which involved the same thirteen staff from the contractors' organisation. This survey is aimed at providing relevant weights to the top ten selected PMIs from the round one survey. The top ten PMIs as selected on round one surveys were then scored on a 5 point Likert scale (see Appendix D) by the respondents. A weighted average formula was then used to interpret the findings and provide weighted averages and relevant weightings expressed as a percentage. This data can then be used as a basis for subcontractor evaluation for the contractors' organisation. A summary of the results is shown below in table 4.4.

	Performance Management Indicators	Survey Results													Weighted Average	Relative Weighting	Relative Weighting (%)	Rank
1	Level of Understanding of Scope	4	5	5	4	5	5	5	5	5	5	4	5	4	4.308	0.106	10.57%	5
2	Communication	3	3	4	4	5	5	4	4	4	4	3	5	4	3.538	0.087	8.68%	8
3	Financial Capacity	3	3	3	3	4	4	3	4	2	4	2	5	3	3.308	0.081	8.11%	10
4	Technical Capability	4	5	5	5	5	5	4	5	5	4	3	5	3	4.462	0.109	10.94%	4
5	Quality	4	5	4	5	5	5	4	5	5	4	4	5	5	4.615	0.113	11.32%	1
6	Adherence to Construction Program	5	5	4	5	5	4	2	5	4	5	5	5	5	4.538	0.111	11.13%	3
7	Honesty and Reliability	3	4	5	5	5	5	4	4	4	4	3	5	4	4.231	0.104	10.38%	6
8	Cooperativeness with main contractor	4	4	4	4	5	5	3	5	3	4	3	5	5	3.692	0.091	9.06%	7
9	Successful past projects	3	2	4	3	4	4	4	4	3	4	2	5	3	3.462	0.085	8.49%	9
10	Commitment Reliability (e.g. Keeping their word)	5	5	5	5	4	5	3	5	5	4	5	5	4	4.615	0.113	11.32%	2

Table 4.4 Summary of the round two survey results

The results shown in figure 4.4 are much closer in range then the round one survey, the range results of the top ten PMIs range from 8.11% to 11.32% relative importance. The results suggest that while some PMIs are weighted higher than others, the spread is minimum and that all PMIs have significance to the contractor. Table 4.5 demonstrates a summary of the round two results in ranked order.

Performance Management Indicators	Relative Weighting	Relative Weighting (%)	Rank
Quality	0.113	11.32%	1
Commitment Reliability (e.g. Keeping their word)	0.113	11.32%	2
Adherence to Construction Program	0.111	11.13%	3
Technical Capability	0.109	10.94%	4
Level of Understanding of Scope	0.106	10.57%	5
Honesty and Reliability	0.104	10.38%	6
Cooperativeness with main contractor	0.091	9.06%	7
Communication	0.087	8.68%	8
Successful past projects	0.085	8.49%	9
Financial Capacity	0.081	8.11%	10

Table 4.5 Summary of the round two survey results

Quality and commitment reliability were rated as the highest weighted PMIs at 11.32%. Third was adherence to construction program at 11.13%. Technical capability closely followed in fourth at 10.94%. Level of understanding of scope came in fifth at 10.57% and sixth was honesty and reliability at 10.38%. Cooperativeness with main contractor was ranked seventh at 9.06% and eighth was communication at 8.68%. Ninth was successful past projects at 8.49% and the tenth was financial capacity at 8.1%.

These relative weightings on the top ten PMIs that the contractor has selected will be crucial when performing the subcontractor evaluations upon practical completion of a typical project lifecycle. Step eight will highlight these PMIs in a practical application.

4.2.3 Design Phase - Step three

Step three in the conceptual process flowchart is to obtain subcontractor feedback on the selected and weighted PMIs identified in the previous section. General feedback on the PMIs was also provided via informal discussions regarding the performance management system and the PMIs selected by the contractor. Five subcontractors were selected based on popular trade disciplines being Electrical services, Hydraulic services, Ceilings and Partitions, Civil and Carpentry. The subcontractors' selected were asked similar to the round two survey, to score the top ten PMIs on a five point Likert scale (refer Appendix E) for analysis. Table 4.6 shows a summary of the results.

	Name	Survey Results					Weighted Average	Relative Weighting	Relative Weighting (%)	Rank
	Round 3 survey									
	Trade									
	Performance Management Indicators									
1	Level of Understanding of Scope	5	5	5	5	5	5.000	0.123	12.32%	1
2	Communication	5	4	4	5	4	4.400	0.108	10.84%	2
5	Quality	5	5	4	4	4	4.200	0.103	10.34%	3
7	Honesty and Reliability	4	5	4	4	4	4.200	0.103	10.34%	4
6	Adherence to Construction Program	4	5	4	3	4	4.000	0.099	9.85%	5
8	Cooperativeness with main contractor	4	4	4	4	4	4.000	0.099	9.85%	6
4	Technical Capability	4	4	4	4	3	3.800	0.094	9.36%	7
10	Commitment Reliability (e.g. Keeping their word)	5	5	5	3	5	3.800	0.094	9.36%	8
3	Financial Capacity	4	3	5	4	2	3.600	0.089	8.87%	9
9	Successful past projects	4	4	4	3	3	3.600	0.089	8.87%	10

Table 4.6 Summary of round 3 survey results

The results shown in table 4.6 have a similar range to the contractors' results of the same PMIs. The subcontractors' rankings of PMIs have a larger range from 8.87% to 12.32% relative importance. The spread is slightly larger however still within a 3.45% range. A summary table is shown in figure 4.7 below.

Performance Management Indicators	Relative Weighting	Relative Weighting (%)	Rank
Level of Understanding of Scope	0.123	12.32%	1
Communication	0.108	10.84%	2
Quality	0.103	10.34%	3
Honesty and Reliability	0.103	10.34%	4
Adherence to Construction Program	0.099	9.85%	5
Cooperativeness with main contractor	0.099	9.85%	6
Technical Capability	0.094	9.36%	7
Commitment Reliability (e.g. Keeping their word)	0.094	9.36%	8
Financial Capacity	0.089	8.87%	9
Successful past projects	0.089	8.87%	10

Table 4.7 Summary of ranked results from round three surveys

Level of understanding of scope was the highest PMI weighting at 12.32%, as opposed to the 10.57% which was ranked fifth according to the contractor's survey results. This may suggest that subcontractors are determined to comply with a full confirming tender in order to reduce any variations within a construction project. Communication was ranked second with a weighting of 10.84% as opposed to the contractors weighting of 8.68% and was ranked eighth. Third was quality with a weighting of 10.34% which was the contractors highest weighted PMI at 11.32%. Quality is the only PMI which is ranked within the top three from both the contractors and the subcontractors' perspective. It is clear that quality rates amongst the highest PMIs within the industry. The results suggest that even with markets tightening and price based criteria still being popular selection criteria for awarding both head contracts and subcontracts respectively, quality still ranks amongst the highest assessment criteria within the construction industry. Fourth ranked by the subcontractors was honesty and reliability at 10.34% (Tied Third). Adherence to construction program and cooperativeness with main contractor was fifth (tied) at 9.85% and technical capability and commitment reliability were seventh (tied) at 9.36%. Finally financial capacity and successful past projects were ninth (tied) at 8.87%.

An informal discussion was undertaken with the subcontractors when gathering the survey data. Generally the subcontractors viewed the performance management system as a good tool that the contractor could use within the industry. One subcontractor was quoted in saying "it looks easy to understand…this is not something that we would do ourselves as a subcontractor but from a general contractors point of view it makes sense". Another contractor when asked about the PMIs selected by the contractor was quoted in saying “I am not sure why there is no price criteria within the assessment...to win jobs traditionally we have to be the cheapest tenderer and usually have to lower our price post tender to get the job”. This was generally the view of all subcontractors and when specifically asked about the absence of priced base assessment criteria one subcontractor was quoted in saying “it is good that we could be assessed without taking price into account…to me this means that people [the contractor] tend to value a quality job over a cheap job”. Overall the response from the subcontractors was positive and all felt that they would be happy to be assessed on the PMIs that were identified within the survey of the contractor’s representatives. If the response from the subcontractors were generally negative, then this feedback would be given to the contractor and further investigation would be required with the possibility of an open discussion on the disconnect between contractor and subcontractor thoughts on performance evaluation, however, as the responses were generally positive the common ground enabled the case study to progress.

4.2.4 Implementation Phase – Steps four-eight

Steps four to eight as identified in section 3.4 could be undertaken if the case study was able to be run in a real time application, however due to the time constraints, the subcontractors that will be used for performance evaluation have been discussed with the contractor and preselected from a series of recently completed projects. As such, these are existing contractors have been used by the contractor, engaged via subcontract agreement and achieved practical completion of at least five projects within the last twelve months. As such the case study will move to step nine which is the post construction stage of the project.

4.2.5 Implementation Phase - Step nine

Now that the surveys to identify and weight the PMIs as selected by the contractor have been completed, step nine in the process flowchart is to use this information to assess the subcontractor based on previous performance. Here the application of the RPA method as identified in section 2.6 of the literature review can be applied with a series of data analysis calculations, the future performance of the subcontractor can be estimated.

Two subcontractors selected in conjunction with the contractor are subcontractor one and subcontractor two. These are two electrical services contractors of similar size and experience who regularly undertake a range of projects with the contractor. The two were discussed and finalised with the contractor based on this and with the recent completion of several construction projects within the last twelve months, made performance evaluations easier to obtain from the contractor. In order to obtain a wider spread of data, five of the latest projects completed by the subcontractors will be evaluated by the relevant contractors' representatives. The template for subcontractor elevation can be seen in appendix F. A summary of the subcontractors' performance evaluations can be seen in tables 4.8 and 4.9 respectively.

Subcontractor 1										
Performance Management Indicators	**Project 1**	**Project 2**	**Project 3**	**Project 4**	**Project 5**	**Mean**	**Weighting**	**Standard Deviation (Variance)**	**Coefficient of Variation**	**Expected Value (Mean)**
Quality	5	5	4	5	4	4.6	11.32%	0.55	0.12	10.41
Commitment Reliability (e.g. Keeping their word)	5	5	5	5	3	4.6	11.32%	0.89	0.19	10.41
Adherence to Construction Program	4	5	5	4	3	4.2	11.13%	0.84	0.20	9.35
Technical Capability	5	5	4	5	4	4.6	10.94%	0.55	0.12	10.06
Level of Understanding of Scope	5	4	3	4	5	4.2	10.57%	0.84	0.20	8.88
Honesty and Reliability	4	4	4	5	4	4.2	10.38%	0.45	0.11	8.72
Cooperativeness with main contractor	5	4	5	5	4	4.6	9.06%	0.55	0.12	8.34
Communication	4	4	3	5	4	4	8.68%	0.71	0.18	6.94
Successful past projects	***3***	***3***	***3***	***3***	***3***	***3***	8.49%	0.00	0.00	5.09
Financial Capacity	4	4	4	4	5	4.2	8.11%	0.45	0.11	6.81
									Total	85.03

Table 4.8 Summary of Subcontractor 1 evaluation results

Subcontractor 2										
Performance Management Indicators	**Project 1**	**Project 2**	**Project 3**	**Project 4**	**Project 5**	**Mean**	**Weighting**	**Standard Deviation (Variance)**	**Coefficient of Variation**	**Expected Value (Mean)**
Quality	3	4	3	3	4	3.4	11.32%	0.55	0.16	7.70
Commitment Reliability (e.g. Keeping their word)	3	5	3	3	3	3.4	11.32%	0.89	0.26	7.70
Adherence to Construction Program	2	4	3	3	4	3.2	11.13%	0.84	0.26	7.12
Technical Capability	2	3	3	2	2	2.4	10.94%	0.55	0.23	5.25
Level of Understanding of Scope	3	4	4	3	1	3	10.57%	1.22	0.41	6.34
Honesty and Reliability	4	5	4	4	4	4.2	10.38%	0.45	0.11	8.72
Cooperativeness with main contractor	5	5	4	4	4	3.2	9.06%	0.55	0.17	5.80
Communication	3	4	4	3	2	3.2	8.68%	0.84	0.26	5.56
Successful past projects	***3***	***3***	***3***	***3***	***3***	***3***	8.49%	0.00	0.00	5.09
Financial Capacity	3	4	3	3	3	3.2	8.11%	0.45	0.14	5.19
									Total	64.47

Table 4.9 Summary of Subcontractor 2 evaluation results

Tables 4.8 and 4.9 show the performance evaluation results for the recently completed five projects, as well as standard deviations, coefficient of variation and the expected values, this information will be used for the RPA method for a prediction of future performance. It should be noted that there was an anomaly discovered with the PMIs when used as a performance evaluation on subcontractors at practical completion. PMI eight which is *successful past projects* does not apply to the performance evaluation of a subcontractor at the practical completion stage. As such, this PMI has been averaged out at three, in order for the assessments to provide an even platform for evaluation. This will be discussed further in the discussion section of this chapter.

Once the initial data has been gathered, the application of the RPA method can be applied to both data sets and can be used as a subsequent comparison. The RPA method will consist of the following analysis calculations:

- Expected value (mean)
- Standard deviation (variance)
- Coefficient of variation
- Range of expected value (prediction of future output performance)

A summary of the results is shown in tables 4.10 and 4.11 respectively.

Summary - Subcontractor 1					
Expected Value	**Standard Deviation (Variance)**	**Coefficient of Variation**	**Confidence Interval (95%)**	**Range of Expected Value for Future**	
85.03	1.751	0.0206	1.252	83.77	86.28

Table 4.10 Summary of Subcontractor 1 RPA analysis results

Summary - Subcontractor 2					
Expected Value	**Standard Deviation (Variance)**	**Coefficient of Variation**	**Confidence Interval (95%)**	**Value for Future Performance**	
64.47	1.283	0.0199	0.9178	63.55	65.39

Table 4.11 Summary of Subcontractor 2 RPA analysis results

It can be seen from tables 4.10 and 4.11 that the expected values of the subcontractors is 85.03 and 64.47 respectively. This is derived simply by the mean average of the performance evaluation scores. It can be seen that subcontractor one has a substantially higher score then subcontractor two.

Once the expected values are found the standard deviation can be found, the RPA method identifies the standard deviation with the level of risk associated with the subcontractor. In a subcontractor comparison, two subcontractors with simular scores could have standard deviations compared and the subcontractor with the lower standard deviation score would statistically have a lower risk of deviating from their expected value score. This is ultimately a decision that the project team should make in subcontractor selection when comparing multiple subcontractors. Equation 4.2 demonstrates the standard deviation calculation.

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

Where:

$\bar{X}$ = Sample arithmetic mean

n = Sample size

X_i = i^{th} Observation of the random variable X

$\sum_{i=1}^{n} X_i$ = Summation of all the X_i values in the sample

Equation 4.2 Standard Deviation (MTSU, 2015)

In this case, the standard deviations for subcontractors one and two are 1.751 and 1.283 respectively. It can be see that while subcontractor one has the higher expected value of performance, their risk profile is slightly higher than that of subcontractor one. This could be explained by some bigger variances in the spread of assessment scores in the contractors performance evaluation of subcontractor one.

The coefficient of variation, being the ratio of the standard deviation to the expected value, shows the expectation of quantitive data. In this situation, the smaller the value, the higher the potential prospective performance that could be achieved by the subcontractor. While the expected value of the two subcontractors differs substantially, if the expected values and risk profiles (standard deviation) were much closer, the coefficient could provide an indication of which subcontractor could provide potentially higher performance for future projects. Subcontractor one and two scores are 0.0206 and 0.0199 respectively. As the expected values differ significantly, the coefficient of variation is not applicable in this case.

The most important calculation of the RPA method is the range of expected value. This also known as a confidence interval and provides a range based on the past performance on how the subcontractors will perform for future works. The confidence interval level can be set at the discussion of the contractor; in this example 95% confidence interval is selected. At a 95% confidence interval, the predictive performance of subcontractor one for future work is ranged between 83.77% and 86.28%. This is minor variation and is an excellent score based on the subcontractor performance evaluations. Subcontractor twos predictive performance of future work is ranged between 63.55% and 65.39%. While the ranges of future performance can be set by the contractor at their discretion, it appears to be an average score based on percentages.

Based on the RPA method as a comparison between the two subcontractors, Subcontractor one has a higher expected value, but also a slightly higher risk profile then subcontractor two. Subcontractor twos expected value on future performance is substantially lower than subcontractor one, and whilst their risk profile may be slightly lower, as a comparison between the two subcontractors, subcontractor one would be recommended for selection over subcontractor two selected for an upcoming project.

4.2.5 Implementation Phase - Step ten

Step ten is to upload this information to the contractors' database. This information can then be stored in a common database to tenderers and project management teams and can be used on future projects at step six of this performance management system.

4.2.6 Implementation Phase - Step eleven

Step eleven aims at providing this information to the subcontractors for feedback upon completion of construction projects. As this is a case study, this information has been provided to the contractor for their review and discretions as to whether this information is to be shared. As this framework is only conceptual and the results are via a test case study, care consideration is taken to as not to damage any relationships between contractors and subcontractors respectively.

4.7 Case study discussion

A representative from the contractors' organisation was consulted based on these results and the process of the process flowchart and RPA method. The feedback was generally positive and the contractors' representative was open to further review of the subcontractor performance management system. "The process flowchart looks fairly straight forward" the contractors' representative stated. "The method of predicting the future performance is a good tool that we could use in future projects to ensure subbie [subcontractor] selection has some science behind it, not just lowest price criteria or that the fact that we might like dealing subbie over another". When asked about the absence of project management framework criteria such as safety and price being absent from the PMIs the contractors representative stated "…this surprises me, in particular any criteria relating to tender pricing. It seems that we seem to value criteria such as quality and program adherence over lowest price. I think that other organisations may have a different opinion on that".

The proposed subcontractor performance management system has been tested in a real life situation though the use of industry personnel input and statistical analysis to determine its relevance within the construction industry. The subcontractor performance management system is designed by the conceptual process flowchart and represents an easy to follow step by step guide to subcontractor selection, engagement, evaluation and feedback. Undertaking the statistical analysis portions of the process flowchart has proven to be simple and user friendly which was the original intent, in that the performance management system should be easy to follow and easy to conform to.

The round one survey which is step one of the process flowchart has 51 preselected PMIs which the contractor's representatives can rank on a user friendly Likert scale. This information can then be collated and using a Relative Important Index calculation as seen in equation 4.1. The PMIs provide a good spread of performance assessment criteria and can be tailored to suit the view of the contractor.

The round two surveys provide weightings for subcontractor evaluation assessment. Whilst the range of values for assessment only resulted in a 3.21% spread, the contractor nonetheless found some PMIs had a higher weighting than others. This step allows the performance management system to be fully customised to suit the needs of the contractor and thought a series of basis calculations, the weights of each PMI could be identified based on the feedback from the contractors' representatives.

The round three surveys provided subcontractor feedback on weightings of the top ten selected PMIs by the subcontractor. While the spread was 3.45%, the subcontractors assessed the PMIs differently to the contractor. Some variance was expected as the survey is done from two different perspectives. While the weightings were within several % of each other, quality was ranked consistently amongst the top three highest weighted criteria for PMIs which suggests that both parties consider quality of work within the highest regards in performance evaluation. The overall consensus from the subcontractors that were interviewed was that the system seemed to be a good way of assessing subcontractors work. Subcontractors were pleasantly surprised about the lack of price driven criteria in the top ten selected PMIs but still felt that price is still a key driver within the industry.

The subcontractor evaluations which represents step nine of the process flowchart was undertaken based on PMIs selected weighted accordingly by the contractor. Here the RPA analysis was used as a basis predicting the future performance of the subcontractors based on previous performance on 5 recently completed projects. Based on the results of the RPA analysis the subcontractors can be estimated at producing an overall future performance at a 95% confidence interval. Subcontractor one whilst having a slightly higher risk profile has a considerably higher expected value for future performance. With a standard deviation of 1.751 and a range of expected value on future performance between 83.77% - 86.28%. Subcontractor two recorded a standard deviation of 1.283 and a range of expected value on future performance between 63.55% - 65.39%. Using the application of the RPA method, subcontractor one should be selected over subcontractor two for future work based on the results provided.

The case study also identified some areas with could be refined in the future. It appeared that PMI #9 was an oddity in the performance assessment of a recently completed project. Successful past projects while a valid PMI in its own right does not does not fit the evaluation method for a contractor specific recently completed project. This is due to the fact that the subcontractor has been engaged for the specific project and their respective performance will be assessed on that project only. Based on this performance evaluation is the application of the RPA method so that future project teams can obtain this data and assist in subcontractor selection based on the previous performance. Further refinement of the original 51 PMIs could be used here so that PMIs that are not suitable for assessing contractors on a recently completed construction project could be omitted from selection during the first round of surveys which represents step one of the process flowcharts. While Successful past projects, previous experience with main contractor and previous experience as a subcontractor are all relevant PMIs, within the post project completion evaluation they are not suited to the application.

Overall, the RPA method is a simple yet effective tool in estimating future performance of a subcontractor based on past performance on previous projects. The conceptual process flowchart appears to be easy to follow within a real world application. Feedback from the contractors and subcontractors representatives appeared to be positive and in line with the overall intention of the performance management system. The subcontractor performance management system appears to have relevance within the construction industry.

Chapter 5: Conclusion

5.1 Conclusions

This research project has sought to investigate the creation of a functional performance management system for principle contractors to assess subcontractors. In order to achieve the project aim it was necessary to achieve the following:

A. Understand relevant literature for the design of a performance management system
B. Develop a guideline for the design of a performance management system
C. Use the guideline and literature research to establish the performance management systems relevance within the construction industry

To understand relevant literature, an extensive literature review had to be undertaken. From this literature review, key factors have been identified, analysed and interpreted in order to establish foundations for the proposed performance management system. The needs of the performance management system have been identified as well a total organisational commitment to the system for effective implementation. 51 key Performance Management Indicators have been identified from the literature review which organisations can tailor to suit the individual needs of their organisation for subcontractor evaluation. Subcontractor licencing within the state of Queensland, Australia has also been investigated, noting the specific requirements in order to be licenced including a series of technical, managerial and financial qualifications.

The literature review also identified Chengs (2014) RPA method for prediction of subcontractors future performance with a calculated level of risk linked to the expected future values. This is an extremely effective tool that can be Intergrated to a contractors database or used as a subcontractor evaluation tool. The modified scorecard approach has been identified has the most beneficial means of evaluation and can be used as a primary means of evaluation for the performance management system. A conceptual process flowchart has been identified as the most beneficial guideline that can be used for the systems implementation. This provides a step by step process which can be easily followed and adjusted to suit the individual systems of contractor's organisation. Finally, an appreciation of the systems benefits have been identified, as there is no use implementing the system without potential benefits that can be achieved as a result of the performance management system. With the use of reduced retention schemes, strategic partnering and decreased risks of issues such as time, cost, and quality on commercial construction projects, the performance management system can yield numerous benefits to a contractor's organisation.

The conceptual process flowchart has been identified from the literature review as the most beneficial means of a framework for the performance management system. This process flowchart can be tailored to suit the individual needs of an organisation and provides a 'one size fits all' 11 step process with a series of hold and decision points which can be easily Intergrated to a contractors existing system.

Finally, a case study has been undertaken in order to establish relevance of the performance management system within the industry. A series of 3 rounds of surveys were undertaken by 13 contractor's participants and 5 subcontractors respectively, to select the top 10 performance management indicators of a contractor's organisation. Using these performance management indicators an application of the RPA method was undertaken and provided future performance predictions of 'Subcontractor 1' between 83.77-86.28% and 'Subcontractor 2' between 63.55-65.39%. While 'Subcontractor 1' had a slightly larger risk profile of 1.751 as opposed to 1.283. The case study identified that some performance management indicators were not suitable for post construction evaluations and this is recommended as future refinements for the performance management system. Feedback from the contractor's representatives and subcontractors regarding the system was generally positive and provides a good indication that the proposed performance management system has relevance within the construction industry.

5.2 Further work/Recommendations

While many industries undertaking subcontracting practices, this research project has highlighted the high volume of work that is subcontracted by principle contractors within the construction industry. This research project was aimed at developing a performance management system framework that principle contractors can use to assess subcontractor's performance; it has provided the key foundations that have been used to develop such a system. However, further work is recommended in order to further evolve the system. Further recommended work includes developing the system for an increased focus on ease of use for the end user, development of the system for automation and further refinement of the system including more testing for integration into a contractors database of subcontractors.

While the conceptual process flowchart developed for the performance management system, is simple to follow and is broad enough that it can in theory, be easily integrated to an existing system, the surveys and data analysis incorporating the RPA method could be evolved to be more user friendly. With the amount of work that principle contractors need to do on a day to day basis, further work is recommended to make the performance management system as easy to use and as user friendly as possible.

One of the ways that this could be done is to implement some automation into the analysis sections of the process flowchart. This could involve the use of an excel template that could use macro formulas to link to an overall database and record historical performance evaluation results. The results could be recorded and linked to a historical spreadsheet and use all of the previous evaluations to get a better spread of performance assessment. This information could then be used to track trends with specific subcontractors and become a much more powerful and effective tool. Other programs such as Microsoft Access provide databases and ease of data entry so the subcontractor evaluations could be done automatically once data is entered at the completion of a project. This information could then again be relayed back to subcontractors to provide feedback from a strategic perspective.

The subcontractor performance management system should also address the refinement issues as identified from the case study, as some performance management indicators are not suitable for post construction evaluations on projects. The list of 51 available performance management indicators could further be refined so that these performance management indicators could be suited to post construction evaluations.

Finally, the performance management system should undergo further testing in real time application, as well as incorporation into an existing contractor's performance management system for trailing. This is essential to the success of the performance management system and is a task that would be specific to each organisation as contractors generally have different operational systems, hence, the need to develop a system that can be implemented from all levels of contractors. Further testing of the system has the potential to produce a powerful performance management system that principle contractors can use to assess subcontractors.

References

(QBCC), Q. B. A. C. C. 2015. *How to Apply for a Trade Contractor or Designer Licence* [Online]. Queensland: QBCC. Available: www.qbcc.qld.gov.au [Accessed 21/4/15 2015].

ABEYSEKERA, V. 2013. Incentivising Subcontractors through Monetary Retentions Australia: USQ.

ANDREA FURLAN, R. G. A. A. C. 2009. Business Relationship Portfolios and Subcontractors' Capabilities. *Industrial Marketing Management,* 38**,** 937-945.

ARDITI, D. R., CHOTIBHONGS 2005. Issues in Subcontracting Practice. *Journal of Construction Engineering and Management,* 131**,** 866-876.

BASSIONI, H. A., PRICE, A. D. F. & HASSAN, T. M. 2005. Building a conceptual framework for measuring business performance in construction: an empirical evaluation. *Construction Management and Economics,* 23**,** 495-507.

CHAN, T. K. 2009. Measuring performance of the Malaysian construction industry. *Construction Management and Economics,* 27**,** 1231-1244.

CHENG, E. W. L. 2014. Risk assessment in prospective performance prediction for subcontractors. *Architectural Science Review***,** 1-10.

CHENG, M.-Y. & WU, Y.-W. 2012. IMPROVED CONSTRUCTION SUBCONTRACTOR EVALUATION PERFORMANCE USING ESIM. *Applied Artificial Intelligence,* 26**,** 261-273.

CHOUDHRY, R., HINZE, J., ARSHAD, M., AND GABRIEL, H 2012. Subcontracting Practices in the Construction Industry of Pakistan. *Journal of Construction Engineering and Management,* 138**,** 1353-1359.

CIDB. 2012. *CIDB Malaysia* [Online]. Malaysia: CIDB. Available: http://www.cidb.gov.my/cidbv4/index.php?option=com_content&view=article&id=456&Itemid=434&lang=en [Accessed 9/4/15 2015].

COMMITTEE, F. U. S. A. B. R. E. 2007. CONSENT FORM FOR PARTICIPATION IN RESEARCH. [Accessed 6/7/15].

COOKE, B. W., PETER 2013. Construction planning, programming and control. *In:* WILLIAMS, P. (ed.) 3rd ed. ed. Chicester: Wiley.

COSTA, D., FORMOSO, C., KAGIOGLOU, M., ALARCÓN, L., AND CALDAS, C. 2006. Benchmarking Initiatives in the Construction Industry: Lessons Learned and Improvement Opportunities. *Journal of Management in Engineering,* 22**,** 158-167.

DAINTY, A. R. J., CHENG, M. I. & MOORE, D. R. 2004. A competency-based performance model for construction project managers. *Construction Management and Economics,* 22**,** 877-886.

DAINTY, A. R. J., CHENG, M.-I. & MOORE, D. R. 2003. Redefining performance measures for construction project managers: an empirical evaluation. *Construction Management and Economics,* 21**,** 209-218.

DICTIONARY, B. 2015. *Performance Management* [Online]. Available: http://www.businessdictionary.com/definition/performance-management.html [Accessed 11/04/15 2015].

DOLOI, H. 2009. Analysis of pre-qualification criteria in contractor selection and their impacts on project success. *Construction Management and Economics,* 27**,** 1245-1263.

ENSHASSI, A., ARAIN, F. & TAYEH, B. 2012. Major causes of problems between contractors and subcontractors in the Gaza Strip. *Journal of Financial Management of Property and Construction,* 17**,** 92-112.

EOM, C., YUN, S., AND PAEK, J. 2008. Subcontractor Evaluation and Management Framework for Strategic Partnering. *Journal of Construction Engineering and Management,* 134**,** 842-851.

EVANS, J. R. L., WILLIAM M. 2014. *Managing for Quality and Performance Excellance,* USA, South-Western Cengage Learning.

FALTA, M. & GALLERY, N. 2011. Unintended consequences of regulatory reporting requirements for small and medium size construction entities: Australian evidence. *Construction Management and Economics,* 29**,** 1121-1135.

GILLEN, G. 2011. *Want Capacity and Performance Management in One Application? Look for a PMDB (Performance Management Database)* [Online]. APM Digest. Available: http://www.apmdigest.com/look-for-a-pmdb-performance-management-database [Accessed 2/3/15 2015].

GIVERNMENT, T. 2015. *Performance Reports for Prequalified Contractors and Consultants* [Online]. Tasmania, Australia: Tasmanian GovernmentAvailable: http://www.purchasing.tas.gov.au/buyingforgovernment/getpage.jsp?uid=4C1F9B61B1F4F980CA256C9400148B03 [Accessed 8/3/15 2015].

HEALTH, B. U. S. O. P. 2015. *Confidence Interval* [Online]. Boston, USA: Boston University. Available: http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704_Confidence_Intervals/BS704_Confidence_Intervals_print.html [Accessed 28/4/15 2015].

JAMES, S. & HAMISH, W. R. 2000. A scorecard approach to benchmarking for total quality construction. *International Journal of Quality & Reliability Management,* 17**,** 453-466.

JITESH, T., DESHMUKH, S. G., GUPTA, A. D. & RAVI, S. 2006. Development of a balanced scorecard. *International Journal of Productivity and Performance Management,* 56**,** 25-59.

KAGIOGLOU, M., COOPER, R. & AOUAD, G. 2001. Performance management in construction: a conceptual framework. *Construction Management and Economics,* 19**,** 85-95.

KUMARASWAMY, M. A. M., J. 2000. Improved Subcontractor Selection Employing Partnering Principles. *Journal of Management in Engineering,* 16**,** 47-57.

LOH, W. H. & OFORI, G. 2000. Effect of registration on performance of construction subcontractors in Singapore. *Engineering, Construction and Architectural Management,* 7**,** 29-40.

LOOSEMORE, M. 2014. Improving construction productivity: a subcontractor's perspective. *Engineering,*

Construction and Architectural Management, 21**,** 245-260.

LUU, T. V., KIM, S. Y., CAO, H. L. & PARK, Y. M. 2008. Performance measurement of construction firms in developing countries. *Construction Management and Economics,* 26**,** 373-386.

MBACHU, J. 2008. Conceptual framework for the assessment of subcontractors' eligibility and performance in the construction industry. *Construction Management and Economics,* 26**,** 471-484.

MTSU. 2015. *Standard Deviation Concept* [Online]. mtweb. Available: http://mtweb.mtsu.edu/stats/regression/level1/meanstdev/stdevconceptdefinition.htm [Accessed 28/4/15 2015].

NG, S. T. 2007. Using Balanced Scorecard for Subcontractor Performance Appraisal. Hong Kong ed. Hong Kong: The University of Hong Kong.

NG, S. T. & SKITMORE, M. 2014. Developing a framework for subcontractor appraisal using a balanced scorecard. *Journal of Civil Engineering and Management,* 20**,** 149-158.

OKOROH, M. I. & TORRANCE, V. B. 1999. A model for subcontractor selection in refurbishment projects. *Construction Management and Economics,* 17**,** 315-327.

PALANEESWARAN, E. & KUMARASWAMY, M. M. 2000. Benchmarking contractor selection practices in public-sector construction—a proposed model. *Engineering, Construction and Architectural Management,* 7**,** 285-299.

QUEENSLAND, U. O. S. 2011. *CMG1001: Studybook,* Toowoomba, Australia, University of Southern Queensland.

QUEENSLAND, U. O. S. 2014. *Contractor Management Procedure* [Online]. Toowoomba, Queensland: University of Southern Queensland. Available: http://policy.usq.edu.au/documents.php?id=13287PL [Accessed 4/3/15 2015].

SERGIO MATURANA, L. F. A., PEDRO GAZMURI AND MLADEN VRSALOVIC 2007. On-Site Subcontractor Evaluation Method Based on Lean Principles and Partnering Practices. *Journal of Management in Engineering,* 23**,** 67-74.

TAM, C. M., DENG, Z. M., ZENG, S. X. & HO, C. S. 2000. Performance assessment scoring system of public housing construction for quality improvement in Hong Kong. *International Journal of Quality & Reliability Management,* 17, 467-478.

TREVOR LO, P. S.-P. W. A. S.-O. C. 2006. Using Balanced Scorecard (BSC) Approach to Measure Performance of Partnering Projects. 17, 45-57.

Appendix A: Project Plan

Research Project 2015 Timeline REV3

																												ch4	ch5	ch5	ch5	ch6	#	#	MS3	PP2					
					Month		March				April					May				June					July				August				September				October				
	DATE ISSUED	20/05/2015			Week No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	[redacted]				Week.	23-Feb	2-Mar	9-Mar	16-Mar	23-Mar	30-Mar	6-Apr	13-Apr	20-Apr	27-Apr	4-May	11-May	18-May	25-May	1-Jun	8-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug	10-Aug	17-Aug	24-Aug	31-Aug	7-Sep	14-Sep	21-Sep	28-Sep	5-Oct	12-Oct	19-Oct	26-Oct
									Milestone 1											Milestone 2															Milestone 3						Milestone 4
Item	**Task**	**Start Date**	**Due Date**	**Milestone Date**	**Duration**																																				
1	**Project Specification**	**23/02/2015**	**18/03/2015**		0																																				
2	Create Mind Map	6/03/2015	6/03/2015		1		1																																		
3	Broard Research on topics relating to areas from Mind Map	6/03/2015	12/03/2015		1		1																																		
4	Narrow searching down to key areas	12/03/2015	16/03/2015		1			1																																	
5	Formulate Specification	15/03/2015	18/03/2015		1			1																																	
6	Milestone 1 - Submit Specification			**18/03/2015**	1				1																																
7	Agreeance on Project Specification	18/03/2015	2/04/2015		2					1	1																														
8					0																																				
9					0																																				
10					0																																				
11	**Preliminary Report**	**2/04/2015**	**3/06/2015**		0																																				
12	Literature Research - Section 1	30/03/2015	3/06/2015		1						1																														
13	Literature Research - Section 2	6/04/2015	13/04/2015									1																													
14	Literature Research - Section 3	13/04/2015	20/04/2015										1																												
15	Literature Research - Section 4	20/04/2015	27/04/2015											1																											
16	Literature Research - Section 5	27/04/2015	4/05/2015												1																										
17	Literature Research - Section 6	4/05/2015	11/05/2015													1																									
18	Literature Research - Section 7	11/05/2015	18/05/2015														1																								
19	Literature Research - Section 8	18/05/2015	25/05/2015															1																							
20	Literature Research - Section 9	25/05/2015	1/06/2015																1																						
21	Research Report Methodology	11/05/2015	3/06/2015														1	1	1	1																					
22	Formulate Template for Research Project	23/03/2015	40/3/15		1					1																															
23	Milestone 2 - Submit Preliminary Report			**3/06/2015**	1															1																					
24	Progress Assessment		17/06/2025		1																	1																			
25					0																																				
26	Partial Draft Dissertation	**3/06/2015**	**16/09/2015**		0																																				
27	Table 2.3 Finalise				1																				1																
28	Survey 1 Finalise format				1																				1																
29	Survey 2 finalise format				1																				1																
30	Generate Participation and consent form				1																				1																
31	Survey 1 issue				1																				1																
32	Survey results				1																					1															
33	Survey 1 analysis				1																					1															
34	Survey 2 issue				1																						1														
35	Survey 2 results				1																						1														
36	Survey 2 analysis				2																						1	1													
37	Survey 3 issue				1																							1													
38	Survey 3 results				2																							1	1												
39	Survey 3 analysis				2																									1	1										
40	Finalise Process flowchart				1																										1										
41	Commence Case Study				3																											1	1	1							
42	Conclusions				1																													1							
43					0																																				
44					0																																				
45	Construct Methodology	8/06/2015	22/06/2015		2																1	1																			
46	Establish guideline process flowchart	15/06/2015	22/06/2015		1																	1																			
47	Format Template Scorecard	22/06/2015	29/06/2015		1																		1																		
48	Round 1 Survey	29/06/2015	6/07/2015		1																			1																	
49	Format Databse Layout	29/06/2015	6/07/2015		1																			1																	
50	Round 1 Survey Analysis	6/07/2015	13/07/2015		1																				1																
51	Round 2 Survey	6/07/2015	13/07/2015		1																				1																
52	Round 2 Survey Analysis	13/07/2015	20/07/2015		1																					1															
53	Perform case Study Example	20/07/2015	3/08/2015		2																						1	1													
54	Discussions from Case Study	3/08/2015	10/08/2015		1																								1												
55	Research Report Writing	10/08/2015	14/09/2015		5																									1	1	1	1	1							
56	Prepare Presentation	10/08/2015	14/09/2015		5																									1	1	1	1	1							
57	Milestone 3 - Partial Draft Dissertation			**16/09/2015**	1																														1						
58					0																																				
59	**Project Presentation Week**	**TBC**	**TBC**		0																																				
60					0																																				
61	**Project Dissertation Final**	**16/09/2015**	**29/10/2015**		0																																				
62	Introductions, Conclusions, Executive Summaries, TOCs Etc.	7/09/2015	28/09/2015		4																													1	1	1	1				
63	Proof Read, finalise format & References	28/09/2015	12/10/2015		2																																1	1			
63	Milestone 4 - Project Dissertation Final Submission			**29/10/2015**	1																																				1

Appendix B: Project Specification

University of Southern Queensland

Faculty of Engineering & Surveying

ENG4111 / ENG4112 Research Project

PROJECT SPECIFICATION
Revision 4

For: Nicholas Linnan

Topic: Creating a Performance Management System for Contractors to assess Subcontractors

Supervisor: Dr Vasantha Abeysekera

Enrolment: ENG4111 – S1 EXT 2015
ENG4112 – S2 EXT 2015

Project Aim: This project seeks to investigate the creation of a functional performance management system for principle contractors to assess subcontractors.

Sponsorship: Nil

Programme: Project Plan_REV1
Issued 7th March 2015

In order to achieve the project aim it is necessary to achieve the following:

A. Understand relevant literature for the design of a performance management system. This will be done by:

1. Identify need for a subcontractor performance management system
2. Identify what is performance management, specifically performance management within the construction industry
3. Investigate what are performance management indicators.
4. Research how subcontractors and builders respectively are licenced within Australia to determine if there is any relevance to a subcontractor performance management system.
5. Research performance management criteria to determine key factors that will influence the development of the subcontract performance management system.
6. Evaluate whether subcontract past performance can be an indicator of future performance.
7. Explore the different types of performance management evaluation methods and determine the most appropriate method to utilise within the performance management system.
8. Understand potential frameworks to be used for the development of the performance management system.
9. Explore the benefits of a subcontractor performance management system.

B. Develop a guideline for the design of a performance management system. This will be done by:

1. Identifying suitable frameworks
2. Selecting a suitable framework
3. Establishing its relevance

C. Use the guideline and literature research in sections A & B to establish the performance management systems relevance within the construction industry. This will be done by:

1. Utilising the system through the use of a case study.
2. Assess the results of the case study to establish the systems effectiveness.

AGREED:

____________________ __________________________

Nicholas Linnan (Student) Dr Vasantha Abeysekera (Supervisor)

10/04/2015 ______/______/2015

Appendix C: Case Study Round 1 Survey

Round 1 Survey

Aim:

To determine the Relative Importance Index (RII) of selected subcontractor Performance Management Indicators (PMIs) that have been identified as part of a construction literature review. The top ten PMIs will then be identified and evaluated for research purposes.

Instructions:

Part A provides information of the survey participants which will be used for data analysis. Please complete by filling in the details as listed in Part A.

Part B provides selected PMIs as identified in the construction literature review, a Likert scale is presented here for convenience. Please complete Part B by ticking the most appropriate box on the Likert scale.

Part A: Preliminary Information

Name:______________________________________

Position:____________________________________

Age:_______________________________________

Experience (Years) in construction industry:_______

Part B: Subcontractor Performance Management Indicators

	Subcontractor Performance Management Indicators	Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
		1	**2**	**3**	**4**	**5**
1	Design Ability					
2	Level of Understanding of Scope					
3	Value Engineering Thoughts					
4	Response to Construction Feedback					
5	Reaction to 'Realistic Costs'					
6	Quality Awareness					
7	Previous Experience as subcontractor					
8	Communication					
9	Financial Capacity					
10	Technical Capability					
11	Reputation					
12	Subcontractors workload					
13	Clients Acceptance of Subcontractor					
14	Tender Price					
15	Quality					
16	Subcontractor References					
17	Geographical Location					
18	Safety					
19	Meeting Attendance					
20	Adherence to Construction Program					
21	Honesty and Reliability					
22	Previous Experience with main contractor					
23	Construction Methodology for site work					
24	Cooperativeness with main contractor					
25	Material Wastage on site					
26	Defects Liability Servicing					
27	Collaboration with other Subcontractors					
28	Workspace Cleanliness					
29	Management Ability					
30	Environmental Impact					
31	Variation Claims					
32	Resource Control (Material, plant, equipment etc)					
33	Contractual Risk (BCIPA & Construction claims etc)					
34	Training and Development of Employees					
35	Employee Satisfaction and involvement					
36	Flexibility in critical activities					
37	Flexibility in non-critical activities					

	Subcontractor Performance Management Indicators	**Strongly Disagree**	**Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
38	Post contract attitude					
39	Willingness to tender					
40	Knowledge of construction regulations					
41	Failure in timely progress claims					
42	Past records on conflicts and disputes					
43	Successful past projects					
44	Employee turnover					
45	Union knowledge and relationship					
46	Current workload commitment					
47	Cost Deviation from tender pricing					
48	Deviation of construction practical completion date					
49	Efficiency of direct labour					
50	Effectiveness of works planning					
51	Commitment Reliability (e.g. Keeping their word)					

Appendix D: Case Study Round 2 Survey

Round 2 Surveys

Aim:

Based on the survey 1 results, the top ten Subcontractor Performance Management Indicators (PMIs) have been identified as the most important to your organisation. This survey aims to provide weighted percentages to these PMIs for a more accurate assessment of your subcontractors. This information can then be used to undertake a Risk Probability Analysis (RPA) to predict the future performance of subcontractors.

Instructions:

Part A lists the top ten Subcontractor PMIs as identified in survey 1. Complete Part A by filling in your name and ticking the appropriate box on the 5 point Likert scale on your assessment of the top ten PMIs. The sum of these weighted averages will then be used in an analysis to determine your organisations weighted percentages in the subcontractor performance management system.

Part A: Top 10 Subcontractor Performance Management Indicators

Name:________________________________

	Subcontractor Performance Management Indicators	**Rank (Scale 1-5)**				
		1	**2**	**3**	**4**	**5**
1	Level of Understanding of Scope					
2	Communication					
3	Financial Capacity					
4	Technical Capability					
5	Quality					
6	Adherence to Construction Program					
7	Honesty and Reliability					
8	Cooperativeness with main contractor					
9	Successful past projects					
10	Commitment Reliability (e.g. Keeping their word)					

Appendix E: Case Study Round 3 Survey

Round 3 Survey

Aim:

To obtain subcontractor feedback from various trade disciplines regarding the selection of the top 10 Performance Management Indicators as selected by the main contractor.

This information can then be used to undertake a Risk Probability Analysis (RPA) to predict the future performance of subcontractors.

Instructions:

Part A lists the top ten Subcontractor PMIs as identified by the main contractor. Complete Part A by filling in your name and ticking the appropriate box on the 5 point Likert scale on your assessment of the top ten Performance Management Indicators.

Part A: Top 10 Subcontractor Performance Management Indicators

Name:________________________________

	Subcontractor Performance Management Indicators	**Rank Scale 1 -5 (Lowest – Highest)**				
		1	**2**	**3**	**4**	**5**
1	Level of Understanding of Scope					
2	Communication					
3	Financial Capacity					
4	Technical Capability					
5	Quality					
6	Adherence to Construction Program					
7	Honesty and Reliability					
8	Cooperativeness with main contractor					
9	Successful past projects					
10	Commitment Reliability (e.g. Keeping their word)					

Appendix F: Subcontractor Evaluation Template

Subcontractor Evaluation Template

Instructions:

Complete this form at project practical completion. Input the information into the subcontractor performance management system and provide results of evaluation to subcontractor in order to facilitate subcontractor's future performance.

Subcontractor:__________________________

Project:________________________________

Subcontractor Contact:___________________

Project Manager:________________________

	Subcontractor Performance Management Indicators	**Rank Scale 1 -5 (Lowest – Highest)**				
		1	**2**	**3**	**4**	**5**
1	PMI 1					
2	PMI 2					
3	PMI 3					
4	PMI 4					
5	PMI 5					
6	PMI 6					
7	PMI 7					
8	PMI 8					
9	PMI 9					
10	PMI 10					

Appendix G: Consent form template

CONSENT FORM FOR PARTICIPATION IN RESEARCH

(By Survey)

Creating a Performance Management System for Contractors to assess Subcontractors

I …..

being over the age of 18 years hereby consent to participate as requested in the Surveys for the research project on the creation of a performance management system for contractors to assess subcontractors.

1. I have read the information provided.
2. Details of procedures and any risks have been explained to my satisfaction.
3. I am aware that I should retain a copy of the Consent Form for future reference.
4. I understand that:
    - I may not directly benefit from taking part in this research.
    - I am free to withdraw from the project at any time and am free to decline to answer particular questions.
    - While the information gained in this study will be published as explained, I will not be identified whatsoever, and individual information will remain strictly confidential.
    - Whether I participate or not, or withdraw after participating, will have no effect on any treatment or service that is being provided to me.
    - Whether I participate or not, or withdraw after participating, will have no effect on my progress in my course of study, or results gained.

Participant's signature……………………………………Date…………………...

I certify that I have explained the study to the volunteer and consider that she/he understands what is involved and freely consents to participation.

Researcher's name……………………………….……………………................

Researcher's signature…………………………………..Date……………………