AN INVESTIGATION INTO REQUIREMENTS ENGINEERING CURRENT PRACTICE AND CAPABILITY IN SMALL AND MEDIUM SOFTWARE DEVELOPMENT ENTERPRISES IN NEW ZEALAND

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

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Abstract

A thesis is presented on current industry practices with respect to requirements engineering as implemented within software development companies in New Zealand. A survey instrument is designed and deployed. The results are analysed and compared against what is internationally considered "best practice" and previous New Zealand and Australian studies. An attempt is made to assess the requirements engineering capability of New Zealand companies using both formal and informal frameworks.

Chapter I Introduction

1.1 Topic

The purpose of this research is to determine some of the factors that affect quality in requirements engineering practice and to discover whether the current practices used in the New Zealand software development industry encompass application of requirements engineering (RE) theory, particularly that relating to process improvement.

The research is built on previous New Zealand studies and results are also compared with those from similar overseas studies.

A literature review was used to source previous studies in New Zealand and overseas for comparison and to determine how requirements engineering quality is measured and what academia deems to be the factors that affect quality.

In order to investigate current New Zealand practice a mixed method approach was adopted with an initial survey of companies whose prime activity is software development or computer consultancy. Following on from the survey, in-depth interviews were carried out with a small number of selected organisations.

1.2 Rationale

Software engineering abounds with stories of project failures. One widely cited report is that of the Standish Group International (1994) which claimed that only 16.2% of software projects succeed when analysed in terms of meeting cost, requirements, time and quality goals (May, 1998), although this study is criticised by many people on the basis of poor choice of cases and lack of transparency. A later study on project management maturity by Price Waterhouse Coopers (2004) found that more than 50% of projects fail and that only 2.5% of organisations consistently meet their project targets, with respect to time, cost and scope. This report cited the main reasons for failure as bad estimates, missed deadlines, scope changes, change in environment, insufficient resources and change in strategy. They also found that a higher project management maturity level enhances overall project performance. (Schwalbe, 2008).

In his book of essays Fred Brooks suggests a number of causes for project failures including poor estimation and missed deadlines (Brooks Jr, 1995). This compares to the work of Korson and Vaishnavi (1992) and Rodrigues and Williams (1997) who suggested that poor

strategic management and related human factors are major causes of failure. Meanwhile Hofmann and Lehner (2001) identify requirements engineering as a key aspect in the success of a software project. Similarly, in their study of Australian software development project practices Verner and Cerpa (2005) found that there was a positive correlation between good and well managed requirements and project success.

From the above it can be seen that missing, poor and changing requirements have all been shown to have a negative impact on project success. It can be argued therefore that good requirements engineering practices that minimise or manage these issues should have a positive influence on project success. But what constitutes good requirements engineering practice and are these practices actually used in New Zealand.? Moreover does the New Zealand software development industry consider such practices relevant, practical or useful?

The online Business Dictionary defines best practice as:
"Methods and techniques that have consistently shown results superior than those achieved with other means, and which are used as benchmarks to strive for. There is, however, no practice that is best for everyone or in every situation, and no best practice remains best for very long as people keep on finding better ways of doing things." (BusinessDictionary.com, 2010). Whilst this definition is somewhat general, Davis and Zowghi (2006) further define a good requirements practice as "a requirements practice that either reduces the cost of the development project or increases the quality of the resulting product when used in specific situations". In this document no attempt has been made to distinguish between the terms "Good Practice" and "Best Practice" and they are used interchangeably.

1.3 Research Question and Objectives

The aim of the research is to determine some of the factors that affect requirements engineering practice particularly within the small and medium sized companies that make up the majority of companies developing software in New Zealand. An additional aim is to discover how New Zealand current practice measures up against both formal and informal process maturity measures. Four research questions are posed:

a) Can capability measures developed overseas be used to assess New Zealand businesses?
b) Have requirements engineering practices in New Zealand changed significantly from those reported in 2000 and 2005?

c) What are the current issues facing RE practice in New Zealand?
d) Are internationally developed "best practices" relevant to New Zealand small and medium sized software development companies?

A positivist approach is proposed leading to the development of the following hypotheses:

a) The capability measures developed overseas can be used effectively to assess New Zealand businesses.
b) Requirements engineering practices in New Zealand have changed significantly from those reported in earlier studies.
c) The issues facing RE practice in New Zealand software development companies are the same as those faced by similar sized overseas companies.
d) International best practices are not relevant to RE practice in small and medium sized New Zealand software development and computer consultancy companies.

1.4 Relevance of Research

According to Cheng and Atlee (2007) requirements engineering research has predominantly focused on finding solutions to specific problems, while only 10–15% of the research effort has been evaluation-based which includes that research which is aimed at assessing the state of current practice.

McConnell (2002) questions why best practices in requirements engineering are not being deployed and suggests "it appears that the challenge for the software industry has shifted from good practice development to good practice deployment" while Fitzgerald (2003) notes that in the past industry practice has preceded academic research in the software development industry. In another article Davis and Hickey (2002) suggested that by doing situational research we could learn which approaches are considered most effective in practice.

The latest data available on New Zealand requirements engineering practice is from 2005 (Phillips, Kemp, and Hedderley, 2005). This study focused on the use of CASE tools, while an earlier study which was undertaken in 2000 (Groves, Nickson et al., 2000a) was concerned with requirements engineering as part of the software development process as a whole. This research is intended to provide a more in-depth snapshot of current requirements practice as opposed to a more general survey that includes an aspect of RE.

The aim is to discover what processes are being followed, the training practitioners have received, and what are the major issues being faced. In answering these questions we will learn where we could focus future research efforts and whether additional training or education in requirements engineering processes may be beneficial.

1.5 Organisation of this Document

Chapter 2 consists of a literature review covering capability assessment tools, and previous studies into requirements engineering current practice in New Zealand and Australia together with relevant overseas studies. Chapter 3 describes the development and deployment of the survey and in-depth interviews. Chapter 4 provides the analysis of the replies while Chapter 5 summarises the conclusions from the findings, reflects on the processes followed in the research and makes recommendations for future investigation.

Chapter II Literature Review

2.1 Scope of Review

The purpose of a literature review is to "provide the reader with a statement of the state of the art and major questions and issues in the field under consideration" (Gill and Johnson, 1991) and it "involves locating, reading and evaluating reports of research as well as reports of casual observation and opinion" (Borg and Gall, 1989). The first part of this review investigates the reasons for measuring capability, discovering instruments for doing so, finding examples of their use and the evaluation of their efficacy.

The second part of the review includes previous New Zealand and Australian surveys that include requirements engineering practice which are analysed to provide information regarding current practice and issues faced. Also included are a number of international studies that focus on small and medium sized enterprises (SMEs). These surveys provide a source of questions that may be asked to provide comparison against the findings from the proposed research as well as a baseline against which any change in practice or issues may be measured.

2.2 Measuring Capability

2.2.1 What is a Capability Measurement?

One of the prime questions to be answered is what is the purpose of measuring requirements engineering capability? Schaeffer (1998) suggests that measuring a company's software capability has four purposes. It should "establish goals for process improvement, set priorities for immediate process improvement options, plan for a culture of product or service excellence and determine maturity of an organisations processes" (Schaeffer, 1998). These purposes can be applied directly to requirements engineering processes, which may be considered a subset of software engineering processes. Therefore if a model is to achieve these purposes then it must address each of them in its measurement.

Among the first instruments designed to measure this maturity is the Software Capability Maturity Model (Software CMM) (Paulk, Curtis, Chrissis, and Weber, 1993). Bamberger (1997), one of the original developers of the Software CMM, gives her view as it being "intended to provide guidelines for managing software development projects and making improvements over time". She goes on to emphasise that these are purely guidelines and are to be adapted to fit the culture of the individual organisation.

Similarly Paulk (1999) describes the Software CMM as intended to "help software organisations improve the maturity of their software processes in terms of an evolutionary path from ad hoc, chaotic processes to mature, disciplined software processes". This view is also held by Sommerville and Sawyer (1997) who define requirements engineering process maturity as "the extent to which an organisation has a defined requirements engineering process based on requirements engineering practices".

The outcome of a capability measurement is that a company is graded on a scale that represents the maturity of its processes, or in other words, how well advanced the organisation is in terms of consistency and completeness, and seeking to continually improve its performance in delivering quality software.

In summary capability measurements are closely linked with management practices related to quality improvement. They are often adopted by companies who wish to demonstrate to potential clients that the company is capable of consistently producing quality products. With the traditional high level of software development project failures as documented in the CHAOS reports (Standish Group International, 1994), (Standish Group, 2004) proof of a company's ability to deliver a quality product can add significant advantage in a highly competitive industry.

Another reason for using a capability assessment tool is that it provides a company with established industry best practice guidelines that will allow the company to increase their productivity and deliver better quality systems.

Some of the major criticisms of the software development process improvement models are that they concentrate more on development and testing rather than requirements (Sawyer, Sommerville, and Viller, 1999), and that processes that relate specifically to requirements elicitation activities are not included in the lower levels of the models (Wiegers, 1996). For this reason specialised RE capability assessment tools have been developed.

Requirements engineering problems have been found to be one of the 10 major factors in software development project failures (Standish Group International, 1994), along with project management and lack of management commitment. It makes a lot of sense therefore to improve the quality of the requirements engineering processes in order to reduce the risk of project failure. It should be noted however, that introducing quality improvement processes does not mean all requirement-related problems in an organisation will be solved.

2.2.2 Capability Assessment Tools

A total of eighteen tools have been identified and a number of articles relating to each of these tools have been selected for review. Of these tools, only five relate solely to requirements engineering. The criteria for inclusion in this section are that the articles are seminal documents that describe the theory behind the tools, or make comparisons between tools. Table 1 lists the tools, the primary classification as to purpose and any links to other models.

As can be seen from this table there are numerous measurements that have been developed for different purposes. The discussion that follows will look at each of these types of measurement in greater depth.

2.2.3 Standards

Differentiation needs to be made between standards and capability assessment instruments. Standards require a company to set in place policies and procedures which can be measured by an outside agency for compliance. Standards are also one-dimensional models – either they are achieved or not achieved and prescribe a minimum quality level. In contrast a capability maturity model awards a grade to a company which in turn provides an opportunity for the company to improve their rating over time by improving their processes. It can also provide a benchmark by which the company can assess itself against others in the industry, provided sufficient data is available. (Sheard, 1997)

The first standards that are noted in the literature are the ISO9000 series. At the higher level these standards are generic, relating to overall business processes rather than addressing activities specific to software engineering. The IEEE 830 1998 standard is specific to Requirements Engineering processes while the ISO 15504 standard relates to Software Engineering.

There are a number of articles that seek to differentiate between the many standards and capability measurement frameworks. One of the more comprehensive articles is that of Sheard (1997) who categorises the purposes of compliance frameworks into Standards and Guidelines, Process Improvement Models and Internal Appraisal methods, Contractor Selection Vehicles, Quality Awards, Software Engineering Lifecycle Models and Systems Engineering Models.

Standards and Capability Measurement Instruments			
Tool	**Type**	**Purpose**	**Based on**
SCE Software Capability Evaluation	Capability Measurement	Contractor Selection	
SDCE Software Development Capability Evaluation	Capability Measurement	Contractor Selection US Air Force	
Inductive Process Assessment	Capability Measurement	Process Improvement	
RAPID (Rapid Assessments for Process Improvement for Software Development)	Capability Measurement	Process Improvement Software Development	SPICE
R-CMM	Capability Measurement	Process Improvement Requirements Engineering	CMM
R-CMMi	Capability Measurement	Process Improvement Requirements Engineering	R-CMM CMMi
REAIMS (Requirements Engineering Adaption and IMprovement for Safety and dependability)	Capability Measurement	Process Improvement Requirements Engineering	Requirements Engineering Good Practice Guide
REGPG	Capability Measurement	Process Improvement Requirements Engineering	Requirements Engineering Good Practice Guide
REMMF	Capability Measurement	Process Improvement Requirements Engineering	
REPM	Capability Measurement	Process Improvement Requirements Engineering	
SEI Maturity Questionnaire	Capability Measurement	Process Improvement Software Engineering	
SECAM Systems Engineering Capability Assessment Tool	Capability Measurement	Process Improvement Software Engineering	
IPD-CMM Integrated Product Development CMM	Capability Measurement	Process Improvement Product Development	CMM
CMM, CMM 1.0 CMM 1.1, CMM-2 Capability Maturity Model	Capability Measurement	Process Improvement Software Engineering	CMM
CMMI	Capability Measurement	Process Improvement Software Engineering	CMM
SPICE Software Process Improvement Capability dEtermination	Capability Measurement	Process Improvement Software Engineering	ISO/IEC 15504
SW-CMM	Capability Measurement	Process Improvement Software Engineering	CMM
Trillium	Capability Measurement	Process Improvement Telecommunications	
IEEE 830-1998	Standard	Requirements	
ISO/IEC 15504	Standard	Software Engineering	
ISO9000, ISO9001, ISO9002	Standard	Software Engineering	
MIL-STD-498	Standard	Software Engineering Life-Cycle Model	

Table 1 Standards and Capability Measurement Instruments

2.2.4 Requirements Capability Measures

The first of the five RE tools in Table 1are REAIMS and REGPG which were developed in 1997. Kauppinen, Aaltio and Kujala (2002) differentiate between these two tools, defining REGPG as a process improvement framework, while REAIMS is a maturity model that is included in the framework. The REAIMS model has three levels and each of the 66 good practice guidelines that Sommerville and Sawyer (1997) have developed is classified as basic, intermediate or advanced. When all the basic guidelines have been implemented then the organisation is graded as meeting the initial level, intermediate guidelines correspond to the repeatable level and advanced guidelines to the defined level.

The basic guidelines relate to "documenting, validating and managing requirements" (Sommerville and Ransom, 2005). The intermediate guidelines relate to use of tools and methodologies while the advanced guidelines are concerned with critical systems development.

Guidelines are scored as never used, discretionary, normal or standardized. A score for each guideline is calculated (0, 1, 2 or 3 respectively) and the basic guidelines scores are summed giving one figure and the intermediate and advanced guideline scores are aggregated to give a second figure. A score of less than 55 (50% of maximum) in the basic guidelines results in a grading of "Initial". "Repeatable" requires a score of 55 in basic guidelines but below 40 (67%) in intermediate/advanced, while to achieve "Defined" the intermediate/advanced score must be greater than 39 and a minimum score of 86 (80%) in the basic guidelines is needed (Sawyer, Sommerville, and Viller, 1997, 1998).

This classification is somewhat confusing in that it does not appear to cater, for example, for a score of between 55 and 86 in the basic guidelines coupled with a score of 40 or higher in the intermediate/advanced guidelines. Presumably this would result in a "Repeatable" classification.

If any guidelines are considered irrelevant to a particular organisation then the maximum figures of 108 and 90 need to be adjusted downwards by 3 to reflect the removal of the guideline from the assessment.

They describe the "Initial" level characteristics as companies using ad-hoc requirements engineering processes where requirements problems are common. At the "Repeatable" level, there are defined standards for requirements documents and process activities. There are

fewer requirements problems than at the "Initial" level, especially for well-understood systems. At the highest "Defined" level there is an explicitly defined RE process based on best practice and there is a process improvement programme in place (Sommerville and Sawyer, 1997).

The second tool is R-CMM This is based on the SW-CMM and was developed by Beecham, Hall and Rainer in 2003. It is a five-level goal-based tool. At level 1 there are no goals defined and RE processes are ad-hoc, resulting in high numbers of requirement-based problems occurring. At level 2 the goal is to introduce repeatable processes and concentrates on the implementation and documentation of standards within projects. The level 3 goal relates to introducing a defined requirements process and focuses on communication and standards across the organisation. Level 4 requires all processes to be measured and managed to assess where improvements could be made. The highest level has a goal of optimising the requirements process which involves implementing new or improved methods and tools (Beecham, Hall, and Rainer, 2005).

This tool assigns sub-processes to each of the levels, allowing sub-processes to be applied in multiple RE phases (elicitation, management, analysis etc). Sub-processes are scored on the approach to the process, broken down into the management approach to the process, the organizational approach and support for the practice; the deployment of the process, broken down into use of the practice, monitoring of the practice and verification of the practice, and finally results broken down into effectiveness of practice, consistency of results and sharing of results/best practice. This is illustrated in Figure 1.

Each item is evaluated and scored as poor (0), weak (2), fair (4), marginally qualified (6), qualified (8) and outstanding (10). This scoring regime is adapted from an instrument used by Motorola (Daskalantonakis, 1994). The approach allows for individual RE phases to be assessed as well as the overall organisational score. The model appears complex and involves scoring large numbers of sub-processes from three different aspects.

The R-CMM model has recently been redefined to bring it into line with the CMMI for Development (Solemon, Shahibuddin, and Ghani, 2009). They have named this R-CMMi. In this version the practices identified for each level are scored as fully implemented, largely implemented, partially implemented, not implemented or not yet. To achieve the specified maturity level all the defined practices must be scored as either fully or largely implemented.

The levels are similar to those outlined in R-CMM being: Level 1 Initial/ad-hoc, Level 2 Managed, Level 3 Defined, Level 4 Quantitatively Managed, and Level 5 Optimising. As with R-CMM goals are specified for each level and practices are identified that will allow the goals to be achieved. This model has yet to be validated.

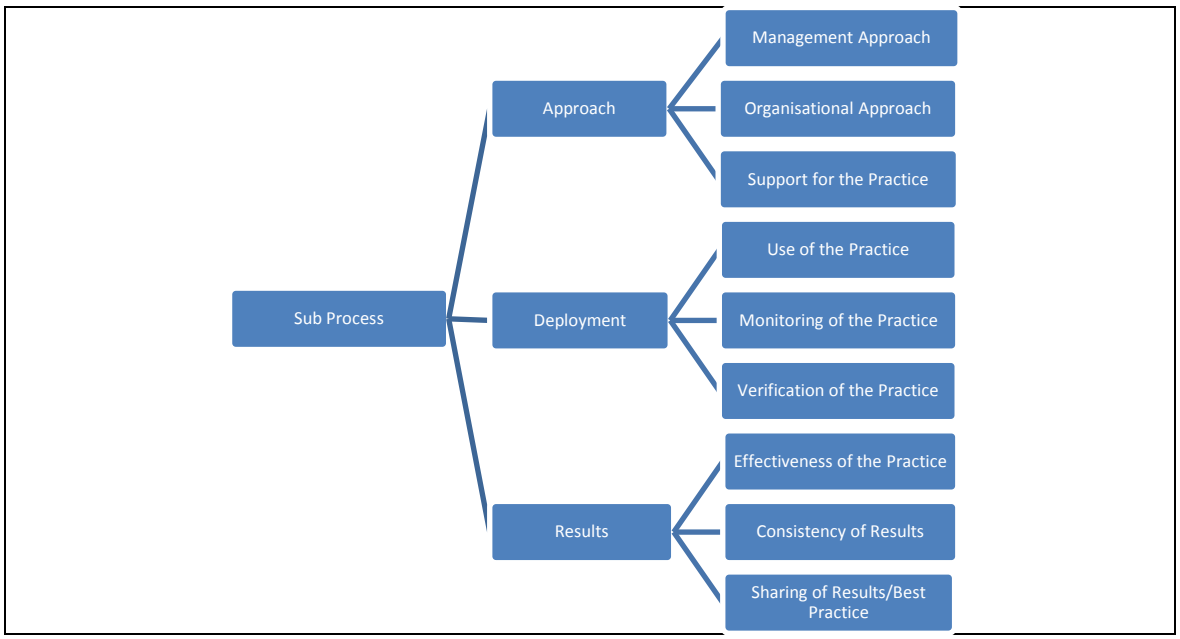

Figure 1 R-CMM Sub Process Breakdown of Scoring Elements

The fourth tool is the REPM (Gorschek, Svahnberg, and Tejle, 2003). It is a five-level model that assigns RE actions into specific levels and determines the maturity level based on whether all the actions identified at each level are being performed. The activities are broken down into those relating to elicitation, analysis and negotiation and finally requirements management. This model was developed specifically for evaluating SME's as the authors argue that the existing models are either too complex (Sawyer, Sommerville et al., 1999) or do not concentrate enough on the RE processes (Konrad, Paulk, and Graydon, 1995; Paulk, Curtis et al., 1993).

This model allows for actions to be completed, uncompleted or satisfied/explained. This latter category is unique to this model. It has been included to recognise that some actions may not be required in a particular organisation and that a satisfactory reason for this has been provided. A satisfactory answer would not include such things as lack of resources or know-how.

The fifth tool is REMMF (Niazi, Cox, and Verner, 2007). This was developed based on the REAIMS model, attempting to remove some of the flaws the authors believe are inherent in the original model, namely ambiguity, confusion and complexity. The authors also used an instrument developed at Motorola for measuring their internal software process status. This instrument looks at approach, deployment and results and scores each of the good practice guidelines using a similar scoring method to that used in R-CMM (0, 2, 4, 6, 8 or 10). The three scores are averaged giving an overall score to that guideline. The scores for each RE process area as defined by Sawyer and Sommerville (1997) are then averaged to provide a score for each area. A score below seven indicates weakness in the area. The model does not appear to give an overall score.

A summary of the main elements of each of the models discussed above is shown in Table 2. Looking at each of these from the viewpoint of ease of assessment, the REAIMS model appears the least complex. It provides an overall rating for the organisation's maturity and an uncomplicated scoring system. However, having only three levels, process improvement is more likely to be measured by changes in the scores rather than movement through the levels.

The R-CMM model requires very detailed assessment and on paper appears complicated to score. It seems more suited to large organisations where processes are carried out by many people, often with different responsibilities. The 5 levels of maturity provide organisations with a series of graduated improvement goals.

R-CMMi looks less complicated than its predecessor. It has retained the five levels of maturity. The scoring is simpler with scoring apparently at the process level, considerably reducing the number of items to be assessed, although an example of the scoring is not given to support this observation. It is in the early stages of development and has yet to be validated.

REPM also defines five levels of maturity. It uses a simple scoring system and allows for processes being considered greater flexibility than the other models in that it allows an organisation to decide whether a particular process is applicable in their context. The REAIMS model does allow for guidelines to be dropped but it is not as transparent as REPM in this respect. The goals and actions are an amalgam of other models, the developers own experience and other industry and academic sources rather than based on

one specific model. The total number of actions is 59, which is seven fewer than the number of items scored in the REAIMS model.

At first glance the REMMF model appears to be an almost unnecessary complication of the REAIMS model. The scoring system is the same as the R-CMM model, and as with the R-CMM model each of the 66 guidelines from the REAIMS model is scored from same three aspects (Approach, Deployment and Results). The developers represent REMMF as a lightweight evaluation tool, however both the REAIMS and REPM models appear less complex and perhaps have a better claim to this. The output from REMMF is at the process level only with no overall organisational assessment being produced.

As this research is concentrating on SMEs, this means that any maturity measurement needs to be easy to administer and allow for processes or guidelines not to be applicable. On this basis the preferred measurements are REAIMS and REPM.

In the next section two informal measurements, which are not based on a rigorous models, are considered as possible indicators of an organisation's requirements capability maturity.

2.2.5 Informal Requirements Capability Assessments

While not formally identified as a capability assessment tool, Nikula, Sajaniemi and Kälviäinen (2000b) used the Sommerville and Sawyer top 10 guidelines as a rough indication of requirements capability in their investigation of small and medium enterprises. Using the same scoring and categories as the REAIMS model the total points were summed and compared against the maximum of 30 points. Of the twelve companies assessed, the highest score was 28, followed by 23, then 17 and the remaining 9 companies scored 7 or less. The authors did not attempt to assign a maturity level, but commented that there was a lot of room for improvement in most of the companies.

The second informal assessment is that used by Groves, Nickson et al (2000a). The researchers combine the replies to their questions on whether a formal language or notation was used in writing the specifications with the replies relating to the existence, documentation and implementation of a specification process to arrive at a classification of a degree of formality surrounding the RE process. Their classifications are shown in Table 3. They make no attempt to relate this to any instrument for capability maturity measurement. The classification is somewhat arbitrary.

2.3 Requirements Engineering Current Practice

Requirements engineering process maturity is only one aspect of current practice. The next part of this review covers surveys that have been undertaken in New Zealand and overseas in order to identify other aspects of current practice that could be investigated. This will cover the methods used in the research, the target population, the types of questions that have been asked and the issues that have been identified.

Comparison of RE maturity measurement instruments

Assessment Tool	Maturity Levels	Based on	Scoring Scheme	Items Assessed	Provides Overall Rating
REAIMS (Sawyer, Sommerville et al., 1997)	Initial Repeatable Defined	Sommerville and Sawyer Requirements Engineering Good Practice Guidelines (REGPG) (1997)	Each guideline scored as Never used Discretionary Normal Standardised	36 basic guidelines 21 intermediate guidelines 9 advanced guidelines	Yes Assessment of main RE processes also possible
R-CMM (Beecham, Hall et al., 2005)	Level 1 Initial/ad-hoc Level 2 Repeatable Level 3 Defined Level 4 Managed Level 5 Optimised	SW-CMM	Each sub-process scored as • Poor • Weak • Fair • Marginally qualified • Qualified • Outstanding	Processes (68 in all) are allocated to each level and these are further broken down into sub-processes, which may be common to more than one RE phase. The sub-processes are then assessed on • Approach to the sub-process • Deployment of the sub-process • Results of the sub-process	Both at RE phase level and overall
R-CMMi Revised (Solemon, Shahibuddin et al., 2009)	Level 1 Initial/ad-hoc Level 2 Managed Level 3 Defined Level 4 Quantitatively Managed Level 5 Optimising	R-CMM and CMMI for developers	Practices scored as • Not yet • Not implemented • Partially implemented • Largely implemented • Fully implemented	Practices are identified in respect of the goals for each level. At the managed level 20 practices have been identified. The number of practices at the other levels is not given	Yes
REPM (Gorschek, Svahnberg et al., 2003)	Five levels numbered 1 to 5	REAIMS	Actions are scored as • Completed • Uncompleted • Satisfied/explained To achieve a level all actions for that level must be completed or satisfied/explained	Goals for each level are specified and actions are assigned to each of three RE phases to achieve the goals 10 actions at level 1 14 at level 2 19 at level 3 11 at level 4 5 at level 5	Yes

REMMF (Niazi, Cox et al., 2007)	Requirements phases are classified as weak or strong	REAIMS	Each dimension is scored as • Poor • Weak • Fair • Marginally qualified • Qualified • Outstanding	Each guideline (66 in all) assessed on • Approach • Deployment • Results	No

Table 2 Comparison of RE maturity measurement instruments

Classification of formality of RE processes - (Groves, Nickson et al., 2000a)	
Classification	**Description**
1	No explicit process and no formal language
2	Clear phases, though any method used is implicit and no formal language
3	Clear phases, and a sequence of informal specifications made during a project
4	Formal process, with semi-formal notation
5	Formal process, with fully formal notation

Table 3 Classification of formality of RE processes

2.3.1 New Zealand Studies

A thorough search has resulted in identifying only four studies of software development practice in New Zealand that have included specific questions about requirements engineering. Only two of these studies (Groves, Nickson et al., 2000a), (Groves, Nickson, Reeve, Reeves, and Utting, 2000b) focus solely on requirements.

In the first study the researchers created a short list of 65 companies and successfully conducted phone interviews with 24 of these. Following these interviews they undertook in-depth interviews with four of the companies. These were selected from the original 24 in that they represented different sizes and types of applications Two or three senior staff members in each of the companies were interviewed. These interviews were the basis of their second study.

In the phone interviews the researchers ask questions around the use of tools and formality of the processes involved as well as establishing whether the companies have implemented any industry, New Zealand or international standards. They identify a number of classifications of the type of development that is taking place to which the requirements engineering process relates.

The reported findings from this research are:

- That the size and type of organisation involved in requirements engineering in New Zealand is extremely varied, as are the types of application.
- The larger the software development team, the more likely that well-defined processes are in place. In addition the larger the team, the more time is spent on RE activities and the more rigorous the testing regime.
- Companies involved in developing software for external clients tend to have better defined or formal processes.

From the in-depth interview a number of issues and opinions were identified. These included:

- Commercial considerations sometimes limit the time allowed for capturing requirements.
- Some viewed standards as costly and not delivering competitive advantage, while others held the opposite opinion, once adopted they are easy to maintain and worthwhile
- Software development processes had been in place less than 2 years in many cases. Other noted that documented processes did not reflect the reality.

The third (Kemp, Phillips, and Alam, 2003) and fourth (Phillips, Kemp et al., 2005) studies covered the broader topic of software engineering practices in New Zealand. The authors were particularly interested in the adoption of CASE tools, specifically those that support a number of activities in the development process.

The third study involved structured interviews with 5 developers asking about the nature of the project undertaken, experience of the developer, size of company and tools used to support project activities. Findings from this study include:

- Case tools were not being used to their potential
- Each of the companies followed some form of procedures for software development
- Less formality was required of developers involved in in-house development as opposed to those developing systems for external clients.

The fourth study used a questionnaire sent to 561 people selected from a business directory that received 147 replies. The questions asked broke the project activities down further than those in the second study. It also focused more on whether the anticipated benefits from the use of CASE tools were being achieved and asked questions about the training received in the use of the tools. Among the findings from this survey were:

- Tools and methodologies are often introduced together
- That use of tools was not mandated

- That integrated tools were not being used mainly because of their complexity and the costs involved
- Many developers placed more importance on processes and methodology than on tools.

The focus of the researchers in all four studies has been on the tools used to support the activities, rather than on any underlying methodologies, although each of them did ask some questions aimed at discovering these.

2.3.2 Australian Studies

A study of 16 Australian companies covered 28 successful software development projects was carried out in 2005 (Sadraei, Aurum, Beydoun, and Paech, 2007) using both questionnaires and semi-structured interviews. The study looked at the total amount of project effort involved in all RE activities and the proportion of total RE effort that each of the RE activities represented. It also investigated the RE processes followed by the companies and compared these against models from RE literature. Of the 28 projects studied only 5 were developed for external customers. Among the findings were that there was a difference in RE effort between internal and external projects and that more structured processes were evidenced for mission critical and external projects. The study also investigated implicit and explicit RE processes, noting that for external projects the processes were more explicit.

A second study covered in-depth research into the issues relating to multi-site software development in one company (Zowghi, Damian, and Offen, 2001). The emphasis in this research was on the Requirements Engineering problems that were experienced and how these were compounded by geographical and cultural differences. The size of the company that was studied is not given, however, given the number and location of sites, it is assumed that the company would be either medium or large, and more likely large. The company was developing a Business Application Environment product that was to be sold and supported from a number of different sites around the world.

Another study (Verner, Park, Cox, Bleistein, and Cerpa, 2005) concentrated on the relationship between Requirements Engineering and project success. This covered both Australian and US companies. This was a large study involving an initial set of interviews followed by a questionnaire which resulted in 143 responses covering 164 projects, 42 of which came from Australian developers. It covered both internal and external projects and

each was classified as either successful or unsuccessful. The majority of the projects were in-house. One of the major findings was that getting good requirements and effectively managing those requirements is a strong predictor of project success. Another finding was that using any software development methodology that includes the RE processes will lead to better results.

2.3.3 Other International Studies

Many of the international studies involve companies that are much bigger than those that characterise the New Zealand Software development industry (El Emam and Madhavji, 1995; Gorschek and Svahnberg, 2005; Gorschek, Tejle, and Svahnberg, 2002; Hall, Beecham, and Rainer, 2002; Lubars, Potts, Richter, Technologies, and Austin, 1993; Neill and Laplante, 2003). Three studies were found that focused on small and medium enterprises (SMEs).

SMEs in the European context are defined as having less than 250 employees, while small companies are defined as having less than 10 employees. Other criteria such as turnover, are also used in the official European Union definition, however the number of employees appears to be the most widely used criterion (Ayyagari, Beck, and Demirguc-Kunt, 2007) and is often the sole criterion for classification.

The first study took place in Germany (Kamsties, Hormann, and Schlich, 1998). It involved a workshop held for 10 companies. This study found that within SMEs

- "The Maturity level of software engineering is very low"
- They typically have "little space for strategic issues such as quality and process improvement"
- "There is a large demand for know-how transfer with respect to basic issues"
- "They are not used to cooperating with external contractors"

The companies also noted that the issues they found most relevant to them were modelling, improvement of the requirements document, inspections and tools.

The second study (Gorschek, Svahnberg et al., 2003) focused on developing a method for RE capability measurement. This model was specifically developed for use in SMEs. Four software development companies were studied, two classified as medium sized (less than 500 employees) and two as small (less than 150 employees). Two companies were located in Ireland and two in Sweden. One of the findings from this study was that the hypothesis that "smaller companies are less likely to have mature RE processes" was not proven. Risk

Assessment was identified as a neglected process and the least satisfactory major process area was Requirements Management.

The third study (Nikula, Sajaniemi, and Kälviäinen, 2000a) surveyed 12 Finnish companies. Three of these had less than 10 employees, five in the 11-50 range and four over 150. For all companies software development represented the major portion of their business. This survey found that there was:

- " A low level of technology transfer in the RE field"
- "A need to improve their RE practices, requiring development of RE process adaptations, RE process improvement and automation of RE practices"

A fourth study, while not specifically aimed at SMEs, concentrated on finding which Requirements Engineering practices could be seen to relate to the success of software projects (Hofmann and Lehner, 2001). This research covered fifteen RE teams undertaking a mixture of customised (nine teams) and package development (six teams). The average project length was 16.5 months and involved 120 person-months. The researchers concentrated on three basic areas. The first was knowledge relating to the application domain, the technology to be used and the RE process to be used. The second was allocated resources, which included team size, effort and project length. The final area was the RE process followed, the extent of definition of the process and the cycles and activities involved.

Using both questionnaires and interviews they developed a set of ten "Best Practices" that they believe contribute to project success. These are:

- Involve customers and users throughout the RE process
- Identify and consult all likely sources of requirements
- Assign skilled project managers and team members to RE activities
- Allocate 15 to 30 percent of total project effort to RE activities
- Provide specification templates and examples
- Maintain good relationships among stakeholders
- Prioritize requirements
- Develop contemporary models together with prototypes
- Maintain a traceability matrix
- Use peer reviews, scenarios and walk-throughs to validate and verify requirements

2.3.4 Comparison of Studies

The surveys discussed above are summarised in the tables below. As can be seen from Table 4, most surveys used either interviews or questionnaires or a mixture of both. Both external and internal projects are represented in most of the studies. The focus of the research varies considerably as does the number of respondents.

Summary of previous surveys

Study	Instrument	Primary focus	Number of Participants	In-house / External
Survey of Software Development Practices in the New Zealand Software Industry. (Groves, Nickson et al., 2000a)	Phone Interview	Use of tools Formality of the RE processes Adoption of standards	24 companies	33% internal 66% external
A survey of software requirements specification practices in the New Zealand software industry (Groves, Nickson et al., 2000b)	In-depth Interview	As above	2 or 3 staff members in each of 4 companies	100% external
Software Engineering Practices and Tool Support: An Exploratory Study in New Zealand (Kemp, Phillips et al., 2003)	Structured Interviews	Adoption of CASE tools	5 developers	60% external 40% internal
Software Development Methods and Tools: A New Zealand Study. (Phillips, Kemp et al., 2005)	Paper questionnaire	Project activities Case tool usage, benefits andtraining	75 people	47% external 53% internal
A field study of the requirements engineering practice in Australian software industry. (Sadraei, Aurum et al., 2007)	Questionnaires and semi-structured interviews	Effort involved in RE activities RE processes followed	16 companies 28 successful projects	5 external projects 23 internal projects
Field Studies of Requirements Engineering in a Multi-Site Software Development Organization: Research in Progress. (Zowghi, Damian et al., 2001)	Field Study over 6 weeks	RE practice in a multi-site software development project	1 company	External
Requirements Engineering and Software Project Success: An Industrial Survey in Australia and the US. (Verner, Park et al., 2005)	Initial interviews followed by a questionnaire	Relationship between requirements engineering and project success	164 projects of which 42 came from Australian developers	Internal and external
Requirements Engineering in Small and Medium Enterprises. (Kamsties, Hormann et al., 1998)	Workshop	Workshop was aimed at providing training for SMEs topics included SRS improvement, elicitation, inspections, modelling requirements, requirements management tools, legal aspects of tendering and subcontracting	10 companies	90% external 10% internal
Introduction and application of a lightweight requirements engineering process evaluation method. (Gorschek and Svahnberg, 2005)	Structured interviews	Development of method for RE capability measurement	4 companies - 2 in Ireland and 2 in Sweden	External
A State-of-the-Practice Survey on Requirements Engineering in Small-and Medium-Sized Enterprises. (Nikula, Sajaniemi et al., 2000a)	Structured interviews	Current RE practices, development needs and preferred ways of technology transfer	12 Finnish companies	Mainly external

Summary of previous surveys				
Study	**Instrument**	**Primary focus**	**Number of Participants**	**In-house / External**
Requirements Engineering as a Success Factor in Software Projects (Hofmann and Lehner, 2001)	Questionnaires and interviews	Identifying which RE practices contribute most to project success	15 projects	Internal and external

Table 4 Summary of previous surveys

The findings summarised in Table 5 also vary, for example the findings relating to the size of project and formality of RE practices (Groves, Nickson et al., 2000a) are actually the opposite of that found in another study (Gorschek, Svahnberg et al., 2003).

Summary of findings of previous surveys	
Study	**Findings**
Survey of Software Development Practices in the New Zealand Software Industry. (Groves, Nickson et al., 2000a)	Larger software development groups tend to have more well-defined software development processes and these are more likely to be used by teams developing for external customers. Size and type of organisation involved in RE in New Zealand is extremely varied as are the types of application
A survey of software requirements specification practices in the New Zealand software industry (Groves, Nickson et al., 2000b)	Commercial considerations sometimes limit the time allowed for capturing requirements Documented processes do not always reflect the reality
Software Engineering Practices and Tool Support: An Exploratory Study in New Zealand (Kemp, Phillips et al., 2003)	Case tools are not being used to their potential Each of the companies followed some form of procedures for software development Less formality was required for in-house development in comparison to development for external clients
Software Development Methods and Tools: A New Zealand Study. (Phillips, Kemp et al., 2005)	Tools and methodologies are often introduced together The use of tools is not mandated Integrated tools are not being used mainly because of their complexity and cost Many developers placed more importance on processes and methodology than on tools
A field study of the requirements engineering practice in Australian software industry. (Sadraei, Aurum et al., 2007)	There is a difference in RE effort between internal and external projects More structured processes were evidenced for mission critical and external projects Processes are more explicit for external projects
Field Studies of Requirements Engineering in a Multi-Site Software Development Organization: Research in Progress. (Zowghi, Damian et al., 2001)	Key problem areas were identified in respect of communication, changes in priorities, inefficient review processes, lack of validation and useful traceability, no significant tool support
Requirements Engineering and Software Project Success: An Industrial Survey in Australia and the US. (Verner, Park et al., 2005)	Getting good requirements and effectively managing those requirements is a strong predictor of project success and using any software development methodology that includes RE processes will lead to better results

Summary of findings of previous surveys	
Study	**Findings**
Requirements Engineering in Small and Medium Enterprises. (Kamsties, Hormann et al., 1998)	The maturity level of software engineering is very low Typically have little space for strategic issues such as quality and process improvement There is a large demand for know-how transfer with respect to basic issues They are not used to cooperating with external contractors The most relevant issues were modelling, improvement of the requirements document, inspections and tools
Introduction and application of a lightweight requirements engineering process evaluation method. (Gorschek and Svahnberg, 2005)	The hypothesis that smaller companies are less likely to have mature RE processes was not proven
A State-of-the-Practice Survey on Requirements Engineering in Small-and Medium-Sized Enterprises. (Nikula, Sajaniemi et al., 2000a)	There is a low level of technology transfer in the RE field There is a need to improve their RE practices, requiring development of RE process adaptions, RE process improvement and automation of RE practices
Requirements Engineering as a Success Factor in Software Projects (Hofmann and Lehner, 2001)	

Table 5 Summary of Findings

Some of the findings were common such as those around the effort and degree of formality involved in external projects as opposed to internal projects (Groves, Nickson et al., 2000a; Kemp, Phillips et al., 2003; Sadraei, Aurum et al., 2007).

In the next chapter the methodology for this research will be outlined together with the processes followed in creating and administering survey instruments as well as analysing the results.

Chapter III: Methodology

3.1 Selection of Data Collection Method

A range of data collection methods can be employed in primary research. These include critical incident technique, diaries, focus groups, interviews, observation, protocol analysis and questionnaires (Collis and Hussey, 2003). Critical incident technique provides qualitative data about particular scenarios. In this type of research the respondent is asked to reflect on specific circumstances, giving information as to what happened and what the result was. This has some similarity to protocol analysis where the respondent is required to provide a description of how they would go about solving a given problem. However in protocol analysis the process is recorded as it happens and could be used with a theoretical problem rather than critical incident technique which takes place after the event and relies on the respondent's memory as to what occurred and the thought processes they followed.

Diaries can be used to record the respondent's thinking over a period of time as well as to capture quantitative information such as how many hours spent on a particular activity each day. They require the respondent to be diligent in recording the required information. Another method for documenting events over a period of time is observation, where the researcher observes and makes notes on what they see. These two methods are particularly useful for establishing what happens on a regular basis but both require considerable effort on the part of the participants where diaries are used and for the researcher if observation is the chosen method.

Focus groups differ from interviews in that a number of participants are gathered together and asked to talk about specific issues. Listening to each other's opinions tends to stimulate discussion, often providing richer information than might be provided if they were interviewed alone. The drawback for this type of research is the need to coordinate the meetings and the amount of time for each focus group. This is easier if the participants are in a small geographical area. Interviews can take a number of forms. In a structured interview questions are scripted and the exact wording is used for each interview. In a semi-structured interview scripted questions are asked and depending on the responses to these questions, further questions are asked that seek additional clarification or detail. In an unstructured interview the respondent is not led in any way, just encouraged to talk about the subject under investigation. Questionnaires are the other major method for collecting information. As with interviews both closed and open questions can be used providing both

quantitative and qualitative information. The advantage of questionnaires over other methods is that a greater number of participants can be studied with a minimal investment in time from both the researcher and the participants. One disadvantage is that there can be a high percentage of non-responses, while another is that, dependent on the chosen distribution method, there may be no opportunity for respondents to seek clarification of the questions.

Looking at the previous surveys discussed in chapter 2 most of the studies used either questionnaires, interviews or a mixture of both methods. One used observation (Zowghi, Damian et al., 2001) and one used a focus group (Kamsties, Hormann et al., 1998). Bearing in mind the objectives of this research, it was decided to use a questionnaire to reach as many participants as possible, and to follow this up with interviews with selected companies.

The questionnaire would contain primarily closed questions that corresponded to those asked in previous surveys, while the in-depth interviews would contain a majority of open-ended questions allowing new information to be discovered and further elaboration of the answers to earlier questions. The interviews would also provide the opportunity to use the more formal instruments for measuring capability, as these involved asking too many questions for them to be included in the initial survey.

3.2 Choice of Survey Instrument

Having decided on a questionnaire the next decision related to the format of the survey. The options considered were on-line, telephone or post. Factors taken into account with this decision were the size of the target population, the cost of administering the survey, the nature of the businesses being surveyed, the expected percentage of replies, turnaround time and time for the researcher to administer, the software to be used and how it would be hosted.

As the budget for the research was limited to NZ$500, the cost of photocopying and posting the surveys together with including a return postage paid envelope, would easily have exceeded the budget. A response rate of 10% was expected using this method (Collis and Hussey, 2003), meaning that at least 300 survey forms would need to be posted in order to ensure a statistically valid return. One of the arguments against using paper forms was that as the businesses that were being surveyed were in the software development industry, it could

be assumed that they would be computer literate and would appreciate being able to fill in a computer based questionnaire and not need to concern themselves with return post.

Telephone surveys were ruled out because of the potential cost of toll calls which could easily overrun the budget as well as the additional time required to conduct a sufficiently broad survey. The alternative approach if telephone were to be used would be to limit the survey to the Auckland area. However this would then mean that the survey could not claim to be representative of the whole New Zealand software development industry, which was one of the original aims of the research.

A search of previous literature featuring on-line surveys showed return rates of 10% (Cater-Steel, 2004; Cater-Steel, Toleman, and Rout, 2005), 12% (Neill and Laplante, 2003) and 14% (Ciolkowski, Laitenberger, Vegas, and Biffl, 2003) which compared favourably with the return rates for paper surveys.

An online survey tool "Survey Monkey" was sourced. The annual cost of US$200 included hosting the survey on their server and a limited amount of analysis of results. This tool provided for creation of a survey with different question types, ability to link to other surveys, keeping responses anonymous. It allowed for both quantitative and qualitative questions, and for the respondent to select from a number of options presented. Questions could be compulsory or optional. Dependent on the options selected for the survey respondents could save and return to the survey at a later date, as well as review and change answers. The results could be exported as either an Excel file or a ".csv" file.

The limitations of the software included the level of analysis available, skip logic only allowing for moving to a new page, not within a page, limited validation of answers and limited amount of narrative. While these factors had the potential to be frustrating, for this particular survey they were not insurmountable and could be overcome by careful question and page design.

3.3 Creation of the Survey

In order to achieve a high return of the questionnaires the number of questions asked was limited to 18 questions. The question design also took into account the amount of explanation needed in order for participants to complete it.

One of the drivers for this research was to build on earlier studies in New Zealand. In Grove, Nickson et al's studies (2000a, 2000b), they derived a rough estimate of capability based on formality of processes and formality of language. The questions that allowed this assessment to be made were included in the questionnaire so that comparison could be made between the responses received and the results of this earlier study. It was decided it was also possible to include the questions on implementation of good practice guidelines relating to the other informal assessment method of RE capability proposed by Nikula, Sajaniemi et al. (2000a).

Also included in the questionnaire were the demographic questions asked by both the Groves, Nickson et al study (2000a) and the Kemp, Phillips et al study (2003). These questions also formed part of the questionnaire used by Nikula, Sanjaniemi et al (2000a) in their survey on RE Practice. The latter survey was used to source additional questions more specific to requirements engineering than those asked in the New Zealand surveys.

Source of Survey Questions

Question	This Study	Groves, Nickson et al (2000a)	Kemp, Phillips et al (2003)	Nikula, Sanjaniemi et al (2000a)
1. What is your Job title?			√	√
2. Number of employees in New Zealand		√	√	√
3. Number primarily engaged in software development		√	√	
4. Number primarily engaged in RE	√			
5. Number involved in RE as a minor part of their job	√			
6. Any employees with formal training in RE				
7. Type of Software Development		√		√
8. Application Types		√	√	√
9. Typical length of Software development projects			√	√
10. Typical no of employees involved		√	√	
11. Requirements Engineering % of total project effort		√		
12. Formality of the requirements engineering process		√		
13. Formality of the language used in requirements specifications		√		√
14. Use of tools to support RE processes		√	√	√
15. Awareness of other tools		√		√
16. Organisation's implementation of requirements engineering practices.				√
17. Top 3 issues facing your organisation with respect to software development and requirements engineering	√			
18. Importance of requirements engineering issues to your organisation?				√

Table 6 Source of Survey Questions

The researcher also created three new questions aimed at establishing whether Requirements Engineering is carried out by dedicated RE specialists or if it is simply a small part of a software developer's duties and to discover whether the people carrying out RE activities had received any formal training in the process. The other new question asked the respondent to identify the top three issues faced by the organisation in relation to software development and requirements engineering.

A list of the questions included in the survey and the source for each question is shown in Table 6. Only questions 1 and 17 are open-ended questions, while for the remainder of the questions the respondent would chose an answer from a number of options presented to them (see Appendix C for details of the options presented for each question). This was done in order to keep the time required to complete the survey as short as possible, while still providing sufficient richness of data to achieve the purpose of the research.

3.4 Creation of the Interview Questions

The intention of the interview questions was to collect information to amplify the answers received in the survey. As with the survey, the topics for the questions were sourced mainly from the same three surveys. The correlation between the questions and the original surveys is shown in Table 7. In contrast to the survey questions, the wording used in the interview questions varied considerably from the original question.

Questions 1 through 8 are essentially new questions. They were included to provide better understanding of the industry's attitude towards education and training in the requirements engineering discipline. Questions 9 to 11 were designed to provide further information about the issues that companies face in respect of RE. Questions 12 and 13 investigate how successful the company considers their projects are while questions 14 and 15 ask about how the company measures quality with respect to RE. Questions 16 to 20 concentrate on any methodologies used and question 21 follows up on the use of tools. The final question is open ended to allow the participant to make any comment about any aspect of requirements engineering.

3.5 Development of Capability Assessment Questionnaire

In keeping the survey brief it was only possible to use the informal methods of measuring capability assessment identified in Chapter 2. These were the assessment based on formality

of process and formality of the specification document used in the original New Zealand survey (Groves, Nickson et al., 2000a) and that based on Sommerville and Sawyer's (1997) top ten guidelines suggested by Nikula, Sajaniemi et al. (2000a). Carrying out in-depth interviews gave the opportunity to use one or more of the more formal frameworks and to compare the results achieved against the informal measurements.

Source of Interview Questions				
Question	**This Study**	**Groves, Nickson et al**	**Kemp, Phillips et al**	**Nikula, Sanjaniemi et al**
1. What are the job title(s) of the person(s) primarily responsible for requirements engineering in your organisation?		√	√	√
2. What are their responsibilities?	√			
3. Please provide details of any, formal education and/or training have they had in requirements engineering? (course name, length and provider – industry, PTE or Tertiary institution).	√			
4. Do you consider there is sufficient literature and training available for requirements engineers?	√			
5. What additional information and training could be provided to assist?	√			
6. What value do you place on industry training?	√			
7. What value do you place on academic training?	√			
8. If university graduates had stronger education in Requirements Engineering, would this be of benefit to your business and why?	√			
9. What are the main areas of concern you have about requirements engineering in your organisation				√
10. Can you expand on your top three issues and the impact they have on your business				√
11. On a scale of 1-10, where 1 is extremely dissatisfied and 10 is extremely satisfied, how satisfied are you with the quality of requirements engineering in your √organisation?	√			
12. What proportion of your projects meet the requirements as documented?	√			
13. What proportion of your projects meet the business requirements for the project?	√			
14. What, if any, quality standards that you are required to meet?		√		
15. How would you measure the quality of your requirements engineering activities?		√		
16. Please describe the methodology do you follow for software development.		√	√	√
17. What issues do you have with it?	√			
18. Please describe the methodology you follow for requirements engineering.		√	√	√

19. What issues do you have with it?	√			
20. Does it cover each of the main activities?				√
21. What, if any, tools do you use to support the following requirements engineering activities?		√	√	√
22. Do you have any further comments about Requirements Engineering in your organisation or in the software development industry?			√	√

Table 7 Interview Question Sources

From the discussion in Chapter 2, it is apparent that the larger capability measurement models (CMM, CMMI, SPICE, R-CMM) are not suitable for use within the New Zealand software development industry which is dominated by small and medium sized companies (SMEs).

This left REPM, REAIMS and REMMF as possible instruments.

For the in-depth interviews it was proposed to use the REAIMS model developed by Sawyer, Sommerville et al. (1997). This model was selected, despite the criticisms that it is too complex (Gorschek, Svahnberg et al., 2003; Niazi, Cox et al., 2007), because the researcher felt that it was the framework which could be most easily applied using a further questionnaire. In addition, by inspecting the answers relating to the top 10 guidelines used as an informal assessment by Nikula, Sajaniemi and Kälviäinen (2000a), the usefulness of this informal tool could be verified.

When the questions that form the capability assessment were added to the in-depth interview questions, it was felt that there were too many questions to be answered. For this reason it was decided to move these questions into a separate document that could be optionally completed. The incentive to complete these additional questions was that companies that did complete the capability assessment questions would be provided with the results of that assessment for their business.

The finalised form based on the Good Practice Guidelines developed by Somerville and Sawyer (1997) is shown in Appendix D.

3.6 Selection of Participants

The New Zealand UBD online business directory was used to source 374 possible participants. This included all companies that were listed under the classification of Software

Development. The companies' web sites were visited to discover contact email addresses. As this information was extracted a number of discrepancies were noted between the websites and the UBD directory. There were a significant number of broken links as well. Where the online directory did not provide a usable link a Google search was used to find the websites. Of the 331 companies listed in this category email addresses were initially found for 155 companies.

In discovering the email addresses it was noticed that a large number of companies do not advertise their email address, instead providing an email form for contacting them. In most cases where an email form was used the email address was not discoverable by viewing the code behind the website. The assumption is that spam is a problem for many businesses and by hiding their email address they do not become a target for unwanted advertising.

3.7 Piloting the Survey

The survey was piloted with three AUT University staff members who had an interest in systems development. Their feedback led to specifically including numbers of contract staff along with employees in the questions relating to number of employees engaged in the various activities. The questions relating to projects were changed to use the word "typical" instead of "average". Changes were also made to some questions to remove ambiguity.

3.8 Ethics Approval

All material that was to be sent to participants was required to be approved by the AUT Ethics Committee, ensuring that participants were made aware of their rights and of any potential risks and how these would be managed.

A Participant Information Sheet was created to be sent to potential participants along with the link to the on-line survey. This sheet covered items such as the purpose of the research and confidentiality issues. See Appendix E. The email invitation containing the link to the survey was developed and included in the submission. This contained a summary of the information included in the participant information. The aim was to keep this as short as possible so that the respondents could quickly find the link to the survey without having to scroll too far down the page. The email invitation is included in Appendix F.

Following the pilot of the survey and indicative interview questions, the recommended changes were made and the revised documents were submitted to the AUT Ethics Committee for approval. These are included in Appendix A. The Committee were

concerned that the participant information be separated from the survey itself. This meant that the participant information, which had originally been included at the start of the online survey, had to be removed and placed in a separate document which would be attached to the email that was to be sent inviting the companies to take place in the research. This had an impact on the number of companies that could be canvassed because email forms could no longer be used for contact as email forms do not allow for attached files.

Another change required related to the wording around informed consent. Originally four separate compulsory questions had been included at the start of the survey. As the survey responses were to be anonymous this was deemed unnecessary and instead the wording "By completing this survey you are indicating your consent to participate in this research." was considered sufficient.

The final change was to ensure anonymity of the replies by separating any company information required to allow the researcher to contact them either for in-depth interviews or to send results of the research from the main survey. This was achieved by creating a second survey which could be invoked from the main survey. The second survey asked for contact details and whether they would be prepared to take part in an in-depth interview and whether they would like to receive a copy of the results. For the finalised questions see Appendix B

No changes to the interview questions were required.

3.9 Administering the Survey

The initial email invitation was sent to 155 companies in the UBD directory. This resulted in 14 responses. Further investigation using Google and follow up on undeliverable emails resulted in a further 27 emails addresses being discovered. From these companies 3 further responses were received. A search of the Yellow Pages online directory identified a further 53 companies and for those 35 email addresses were found. A second email was then sent to those businesses resulting in 3 more responses, giving a total of 20 responses in all.

As it was felt that this was not a high enough number of responses, it was decided to include the category "Computer Consultancy" from the on-line directories. Surprisingly there was very little overlap with the businesses listed under "Software Development". Using this criterion 338 companies were discovered for which 184 email addresses were found using the same procedures as earlier. The email invitation was sent to these companies resulting in 10 additional responses, bringing the total number of responses to 30..

3.10 Processing of Replies

The replies were downloaded from the SurveyMonkey server in the form of an Excel workbook. A csv format file was also created. Two options were available for the Excel format, one which showed the actual option selected, while the second translated the option into a numerical format where appropriate retaining any open ended text replies.

The first option was useful for importing the replies into tables. The drawback was that Excel interpreted some replies as date where in fact they were a number range. An example of this was the reply "3-5" which Excel interpreted as 3rd May. This was overcome by creating a lookup worksheet to correctly interpret the numerical format.

This data was then loaded into SPSS and some initial analysis was performed, with statistical data such as medians, means, standard deviations etc being calculated. The data was tested for any correlations between the replies to different questions. SPSS output was exported as a rich text file which could be inserted into this document.

The next step was to make the comparisons of the results with other surveys on a question by question basis. The final step was a manual review of the replies to check for consistency of answers and to compare and contrast the replies to the open ended questions.

The detailed findings are described and analysed in depth in the next chapter.

3.11 In-depth Interviews

From the replies received 10 respondents indicated that they would be interested in participating in further research. The original list of indicative interview questions was amended slightly to add additional open ended questions around training and education in Requirements Engineering and also to request further elucidation around the top three issues that they had identified in the original survey.

It was also decided to keep the Capability Assessment questions as a separate optional questionnaire because it was felt that there would be too many questions if these were included in the main interview. Companies could then be offered the opportunity to have an assessment made and to receive company-specific feedback as opposed to the more general results from the surveys and interviews.

The 10 companies were contacted via the email addresses they supplied. The interview questions were attached as a protected form and the participants were given the option of completing the form and returning it or providing a suitable time for the researcher to contact them.

Of the ten, only three replied to the email. One said that they were too busy to be able to participate. Another declined, saying that they felt the interview questions were biased towards traditional RE methods and that they used prototyping instead and consequently felt that the questions were irrelevant. The third respondent completed the interview questions form and returned it to the researcher.

The replies from the third company are described and discussed in detail in the next chapter as are the comments received from the prototype exponent.

Chapter IV: Findings and Discussion

4.1 Description of Findings

4.1.1 Survey

4.1.1.1 General Comments

In this section the responses to each of the questions are shown and comparisons are made with other surveys. The results are analysed and some initial conclusions are drawn. The full tabulated responses are shown in Appendix G.

4.1.1.2 Job Title

As can be seen from Figure 1Figure 2, a large majority (86.67%) of the respondents identified themselves as having managerial responsibilities, with only 4 claiming a purely technical role. Only one respondent described themselves as having primarily RE activities giving their title as Business Systems Analyst. The remaining technicians described themselves as software developer or analyst / programmer. This result was unexpected and highlighted the need to be more specific in the way this question is asked. While it is possible that many of those who gave their title as director or similar designation could also be technicians, this cannot be assumed. What it does mean is that the responses represent a management viewpoint rather than that of technicians.

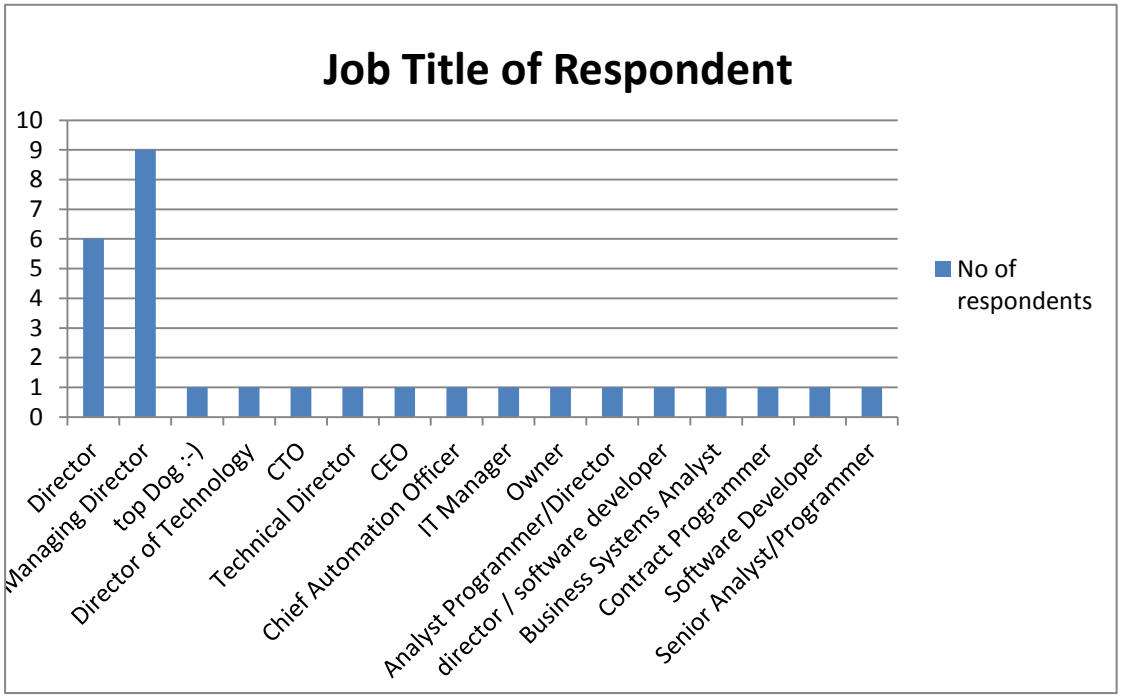

Figure 2 Job Title of Respondent

No comparison can be made with Groves study as this question was not asked in their interviews nor is it stated whether they targeted technicians or managers. However all the other studies covered in the literature review (Gorschek, Tejle et al., 2002; Kamsties, Hormann et al., 1998; Kemp, Phillips et al., 2003; Nikula, Sajaniemi et al., 2000a; Phillips, Kemp et al., 2005; Sadraei, Aurum et al., 2007; Verner, Park et al., 2005; Zowghi, Damian et al., 2001) were carried out canvassing technicians rather than management.

4.1.1.3 Number of Employees

Looking at the size of company, 93% (28 companies) would be classified as small (20 or fewer employee) while the remaining 7% (2 companies) classified as medium (21 to 50 employees) using the classification adopted by Phillips et al (2005).

These results are in contrast to other studies which have a much wider spread of company size. However they are consistent with New Zealand Government official company statistics which show that 97% of New Zealand companies have fewer than 20 employees (Statistics New Zealand, 2009).

As mentioned above the Phillips, Kemp et al (2005) study targeted software developers rather than companies. It also differed from this study in that it covered all industries, not just software development and computer consultancy companies which represented 47.5% of their respondents. A rough calculation using the midpoint of the range to represent the average number of employees in that group shows the average number of employees in this study is 8.7 compared with 15.3 in the Phillips, Kemp et al (2005) study. This size difference may also show in the other questions that relate to number of employees.

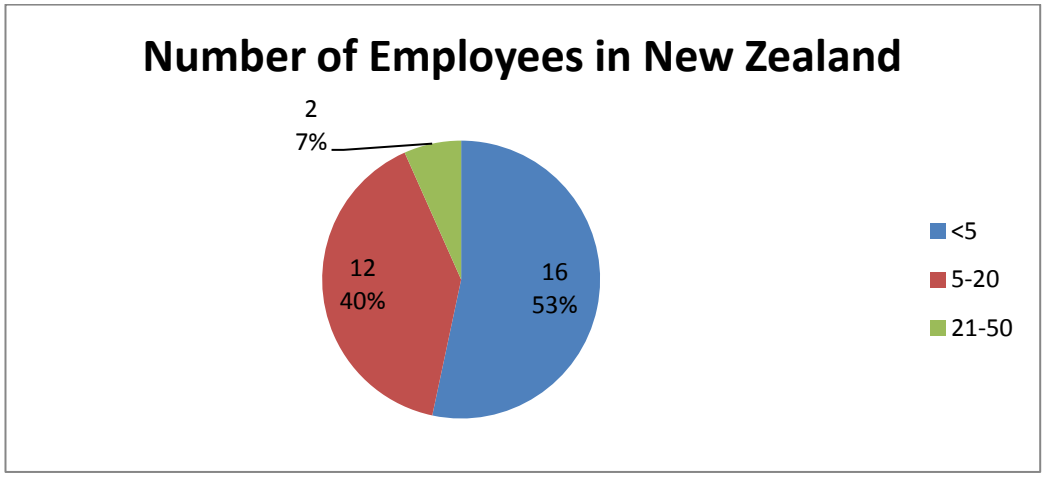

Figure 3 Number of Employees

4.1.1.4 Number Primarily Engaged in Software Development

Figure 4 summarises the responses received. These figures reflect the targeted population of software development and computer consultancy companies. There is a positive correlation ($R^2 = 0.5319$) between the number of employees and the number engaged primarily in software development as illustrated in the scatter diagram shown in Figure 5 One exception to this trend is respondent number one, who said that less than 3 of their five to twenty employees are involved in systems development while three to five are involved primarily in requirements engineering and 11-20 involved in requirements engineering as a minor part of their job. It appears therefore that this respondent does not consider requirements engineering as part of the systems development process.

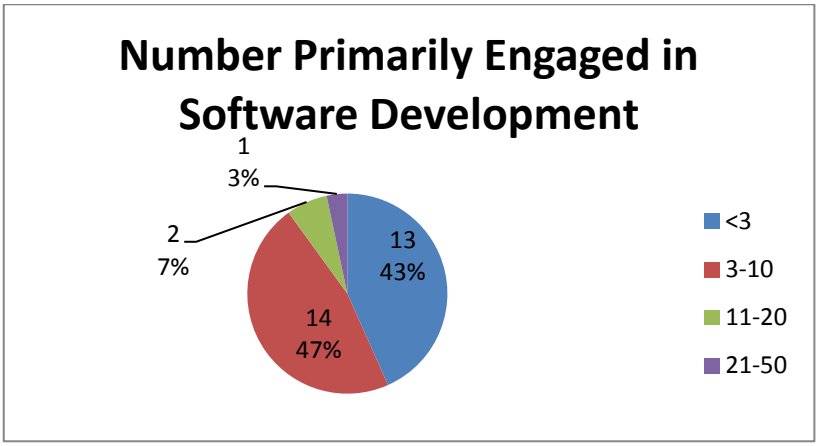

Figure 4 Number of Employees Primarily Engaged in Software Development

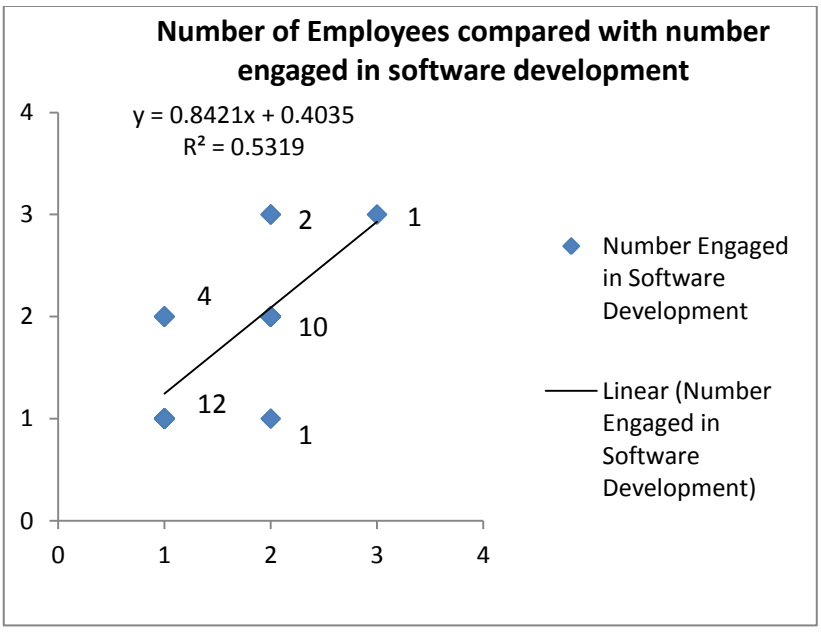

Figure 5 Number of Employees vs Number Engaged in Software Development

4.1.1.5 Number primarily involved in RE

These figures indicate that 67% of the companies have dedicated requirements engineers. As this was a new question, no comparison can be made with other studies, however, given the comparatively small size of the companies, this was an unexpected result. Further analysis of the answers showed that eight out of the ten companies reporting no employees engaged primarily in Requirements Engineering have less than five employees and less than 3 employees engaged in software development. The other two companies both had more than 20 employees more than 10 of whom are primarily engaged in software engineering. One of these companies reported more than 10 employees are involved in RE as a minor part of their job, while the other reported that none were involved in RE as a minor part of their job. This same respondent identified that some of the employees have had formal training in Requirements Engineering, thus indicating an understanding of the term. One possible explanation for this response is that this company is involved only in developments where the Requirements Engineering is undertaken by another party.

There appears to be little correlation ($R^2 = 0.0573$) between the the number of employees in the company and the number or employess primarily engaged in RE as shown in figure Figure 7.

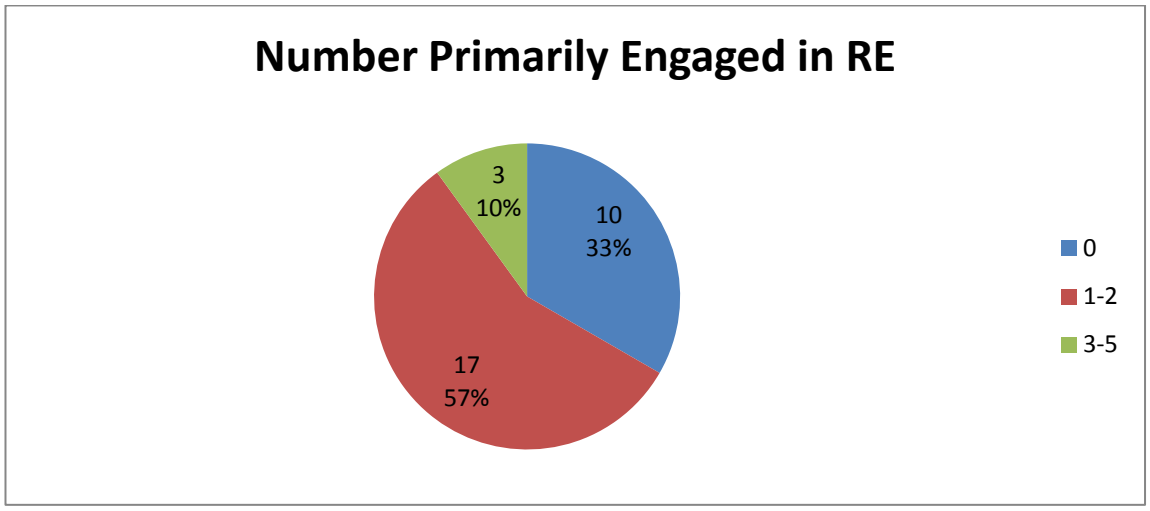

Figure 6 Number Primarily Engaged in RE

4.1.1.6 Number involved in RE as a minor part of their job

This question aimed at finding the number of employees for whom Requirements Engineering is only a small part of their job. Only six companies (20%) indicated that none of their employees were in this category and four of these companies reported having employees whose primary responsibility is Requirements Engineering. The other two

companies are respondent number 28, which is discussed in the previous paragraph and respondent number 15. This latter company has either 3 or 4 employees engaged in software development and reported that none of their employees have any formal training in Requirements Engineering. It is possible that in this case the term requirements engineering may not have been understood by the respondent who identified themselves as the Managing Director. Interestingly this same respondent cited eliciting requirements as their number 1 issue later in the survey. From this and the other answers it seems that this company may also rely on another party to develop requirements specifications for them.

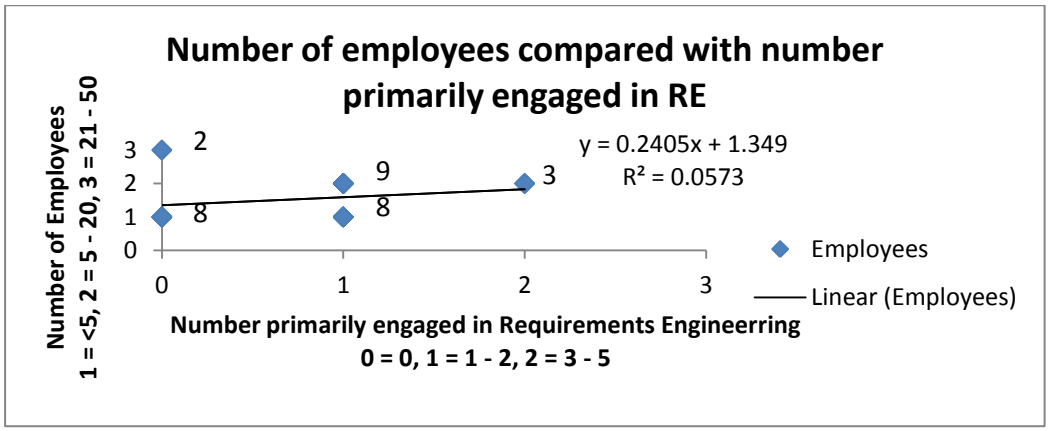

Figure 7 Number of employees compared with number primarily engaged in RE

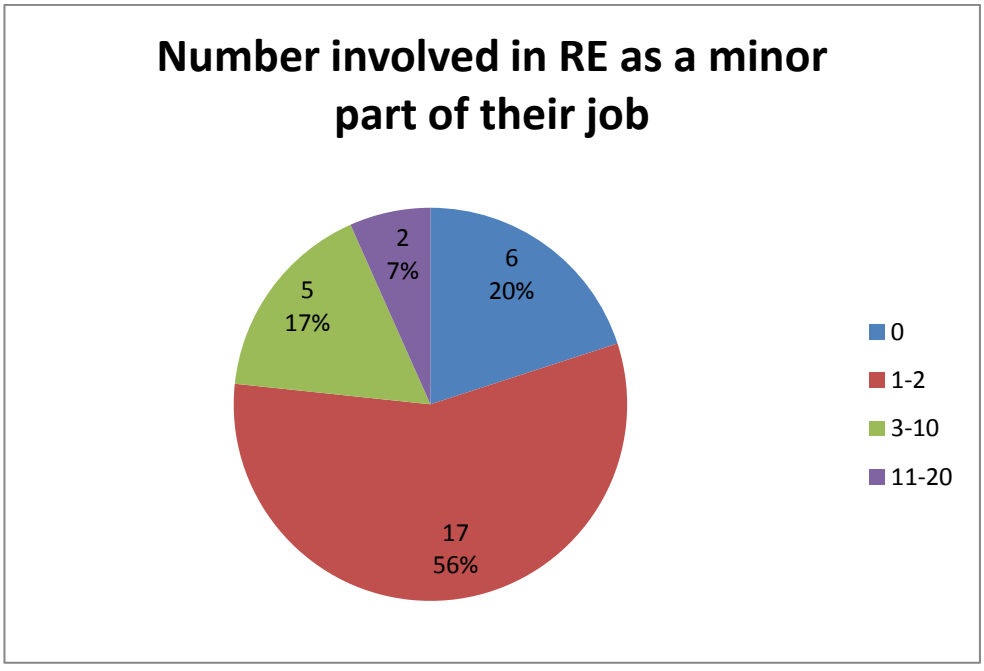

Figure 8 Number involved in RE as a minor part

4.1.1.7 Any Employees with Formal Training in RE

The intention of this question was to discover whether those involved in Requirements Engineering have undertaken any formal training in the process. Ideally those primarily involved in Requirements Engineering would be expected to have some formal training. The wording of this question was slightly confusing as it failed to restrict responses to just those involved in RE. However, the results indicate that 64% of companies have employees with some formal training. Of those that indicated that none of their employees have had formal training (11 companies) only one of these reported as having no involvement in RE activities while five of them have employees whose primary task is RE. This means that in at least 25% of the 20 companies with RE specialists, those specialists are without formal training.

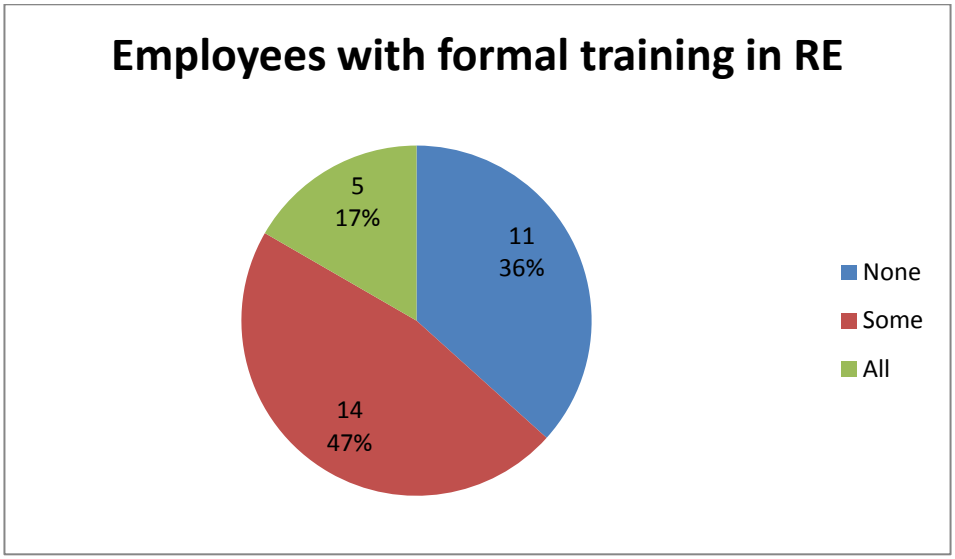

Figure 9 Employees with formal training in Requirements Engineering

4.1.1.8 Types of Software

The first question aimed at identifying the type of development that was undertaken. The results showed a mix between customised, one-off and package development.

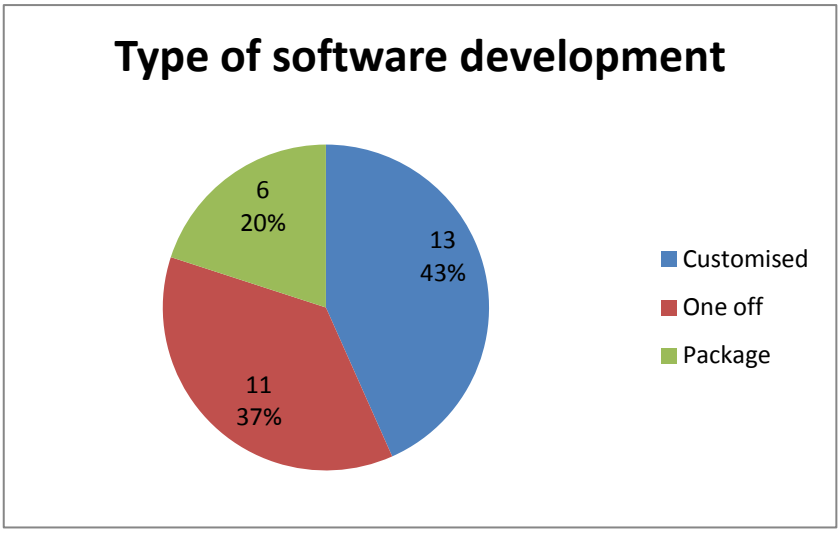

Figure 10 Types of Software Development

Comparing these results with other studies it can be seen that there is little correlation between the types of development amongst the various studies as can be seen in Table 8 below.

Comparison of types of software development					
	This study	**Groves, Nickson et al (2000b)[1]**	**Sadraei, Aurum et al. (2007)**	**Nikula, Sajaniemi et al (2000a)**	**Kamsties, Hormann et al. (1998)**
Customised	43%	29%	18%	23%	10%
One-off	37%	53%	82%	45%	90%
Package	20%	18%		32%	

Table 8 Comparison of types of software development

4.1.1.9 Application Types

This question sought to establish the types of applications being developed. Respondents were asked to rank each of the given application types as being developed never, sometimes, often or always. Respondents could select as many application types as they wished. Figure 11 shows the frequency of development of the different applications, while Figure 12 shows the totals for each application type regardless of frequency. Replies of never or no response have been excluded from these results. From these it can be seen that all application types were well represented within the sample. Comparing results against previous surveys it is noted that there is a close correlation between the applications reported in the Phillips Kemp

[1] More than one classification was recorded against individual companies so results add to more than 100%

et al survey. This is shown in Table 9. Unfortunately, while Groves, Nickson et al asked the same question, the replies are not included in their papers and so it is not possible to include this survey in this comparison. None of the other surveys used the same classification scheme for applications.

Comparison of software development applications		
	This Survey	**Phillips, Kemp et al (2005)**
Management Information	21%	25%
Transaction Processing	21%	24%
Real Time	12%	14%
Web	22%	21%
System	8%	8%
Embedded	8%	8%
Other	8%	

Table 9 Comparison of software development applications

Other applications that were listed were server technologies, engineering software development, scientific applications or integration of applications, integration to 3D CAD systems and web applications.

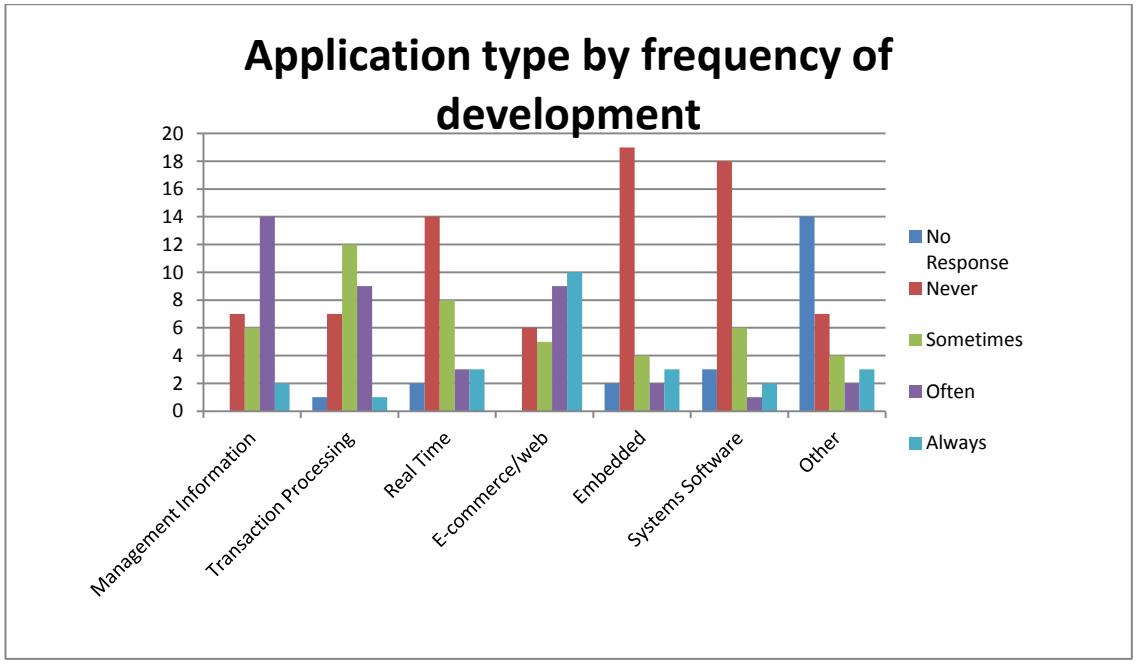

Figure 11.Application type by frequency of development

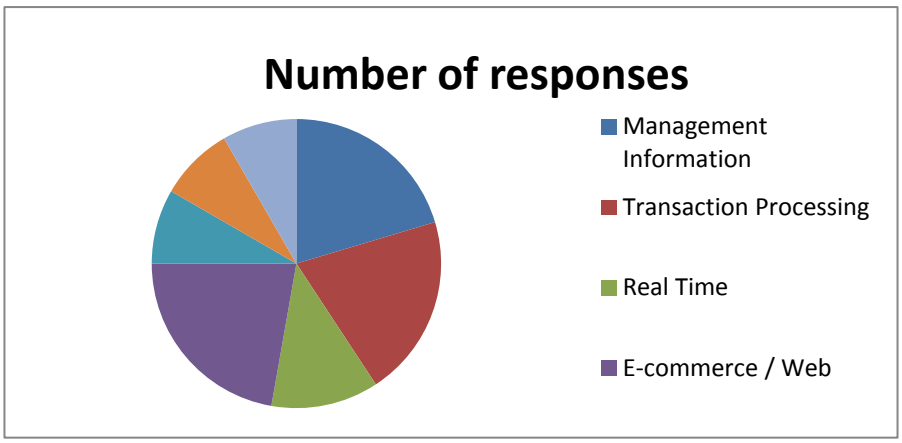

Figure 12 Total for each application type

4.1.1.10 Typical Length of Projects

As can be seen from Figure 13, only 17% of projects are typically longer than 6 months, and 84% were typically between 3 months and a year. Given the generally small size of the companies involved this is not an unexpected result. The Phillips, Kemp et al survey (2005) reported that of the projects reported on 60% of the respondents worked on a project lasting between 3 months and one year. However direct comparison may not be valid as in the latter survey respondents were reporting on a single project, while this research asked for the typical length of a project requiring the respondent to consider more than one specific project.

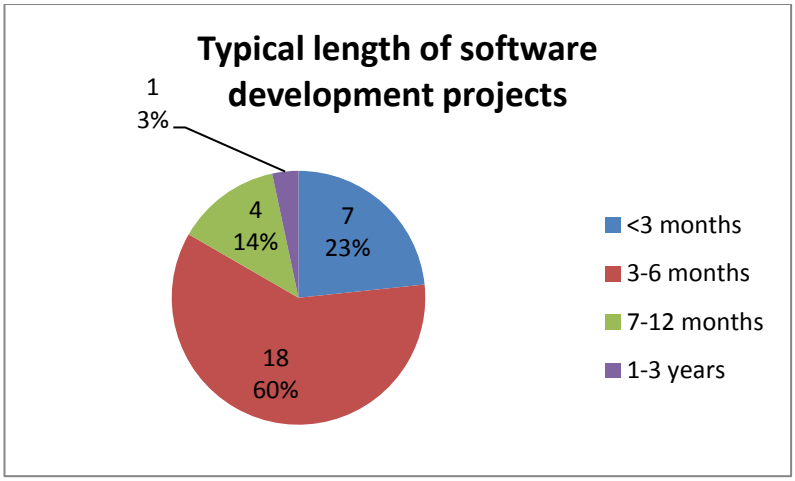

Figure 13 Typical length of software development projects

4.1.1.11 Typical Number of Employees Involved in Projects

This question, as the previous question did, looked at getting a picture of a typical software development project. The results are shown in Figure 14. Combining the two sets of

answers it can be seen that typically the projects are of a short duration (6 months or less) and involve only one or two employees. Using the classification scheme from the Groves, Nickson et al (2000b) study, projects with less than 4 people involved would be small, and those with four to nine people involved medium, then all the projects are either small or medium sized.

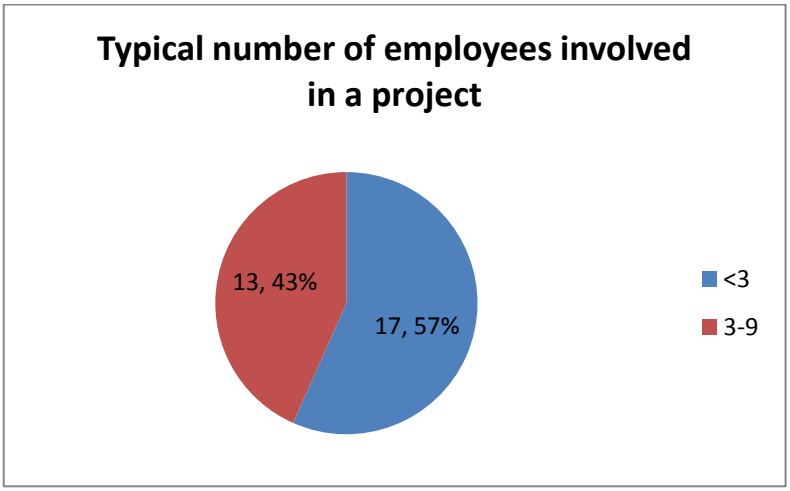

Figure 14 Typical number of employees involved in a project

Also, as Figure 15 shows, there is no significant correlation ($R^2 = 0.0186$) between length of project and number of employees involved. The comparative project sizes are shown in Table 10. This shows that the typical number of participants is similar to the findings of the Phillips, Kemp et al. (2005) study, while the projects studied by Verner, Park et al (2005) were on average much larger .with only 63% of projects having 9 or less participants.

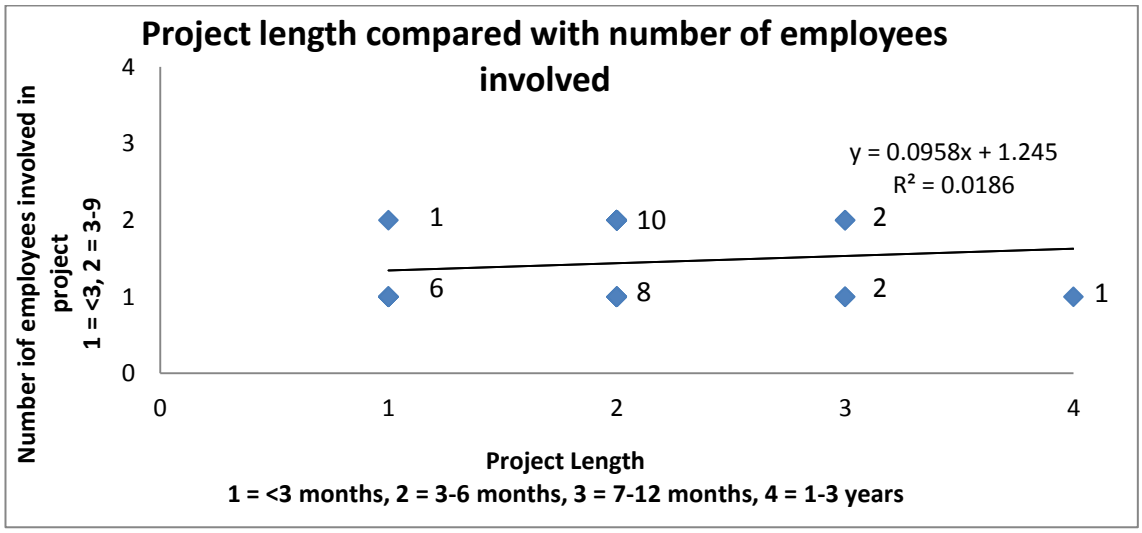

Figure 15 Project length compared with number of employees involved

Comparison of project size by number of participants					
This Study		Phillips, Kemp et al. (2005)		Verner, Park et al (2005)	
< 3	57%			1-4	39%
3-9	43%	< 9	86%	5-9	24%
		10-20	7%	10-19	19%
		21+	7%	20-29	5%
				30-39	4%
				40-99	6%
				100-180	8%

Table 10 Comparison of project size by number of participants

4.1.1.12 Requirements Engineering as a Percentage of Total Project Effort

This statistic has been included in a number of studies, with their findings showing a wide range of results. The responses in this study also showed a wide variation ranging from 0-5% to 50-55%. The mean is 18%, the standard deviation 12.13% and variance 1.5%. This is a much wider variation than that recorded by MacDonell and Shepperd (2003) but is consistent with the findings of Groves, Nickson et al (2000b). The mean is close to that reported by Chatzoglou and Macaulay (1996), but higher than Groves Nickson et al study (2000b). Table 11 below includes Sadrei, Aurum et al's (2007) summary of the results of previous international studies together with the findings from this survey and one of the New Zealand studies.

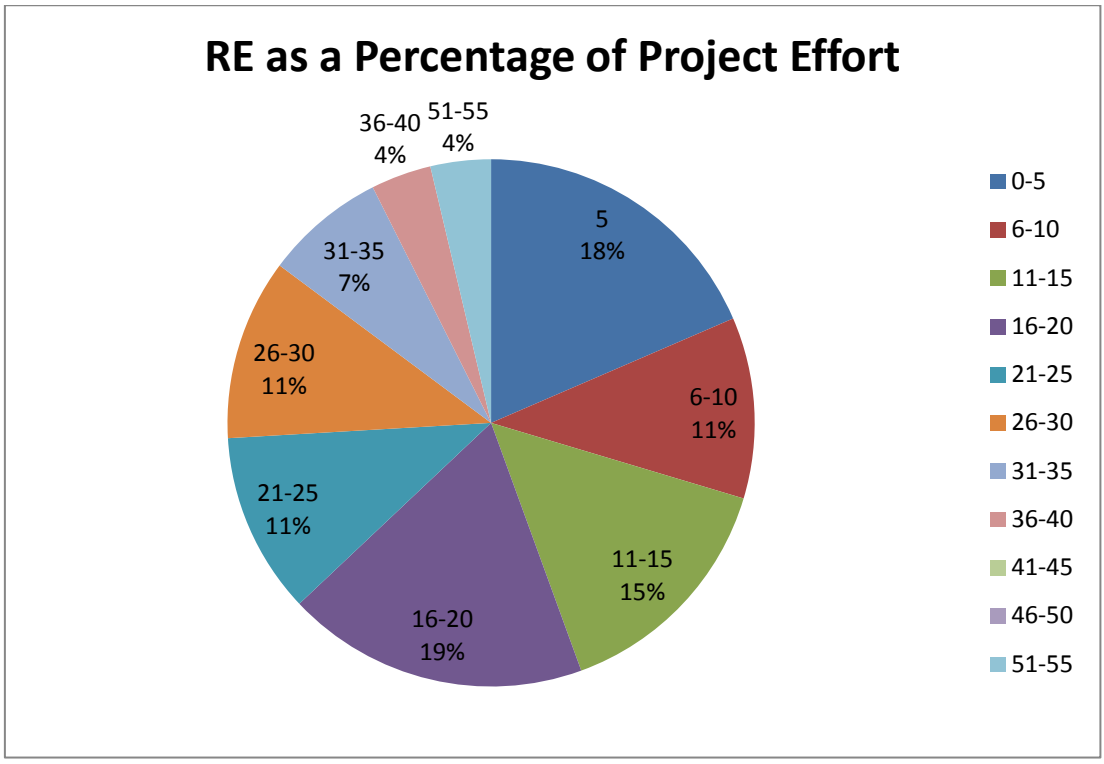

Figure 16 Requirements Engineering as a Percentage of Total Project Effort

Studies on RE effort distribution	
Author	**Findings**
Alexander and Stevens (2002) (experience)	5% of project effort (not including system specification). For smaller projects up to 25% of the project (not including system specification)
Boehm (2007) (experience)	6% of total cost of software development
Chatzoglou and Macaulay (1996) (107 projects)	15% requirements capture and analysis of elapsed time
Groves. Nickson et al (2000b) (24 companies)	Range 10% to 60%, average 27%
Hoffman and Lehner (2001) (15 projects)	RE effort is 15.7% of project effort (time). For successful projects 6.4% elicitation (39% RE effort), 6.2% modelling (36% RE effort), 3.1% validation and verification (25% of RE effort).
MacDonell and Shepperd (2003) (16 projects)	Range 0 – 11%, average 2%. Too much variance in effort (time) in project planning and requirements specification
Sadrei, Aurum et al (2007) (28 projects)	Investigated breakdown effort for RE phases but not total RE effort as a percentage of total project
This study (28 companies)	Range 0-5% to 50-55%, average 18%

Table 11 Studies on RE effort distribution

4.1.1.13 Formality of RE Process

This is the first of two questions designed to give an informal measurement of the maturity of the RE process of the organisation. The intention of this question is to establish the degree of formality of the RE process in respect of how well it is defined, documented and followed. The responses showed no positive correlation (R^2 = 0876) between the number of employees involved in software development and the degree of formality as indicated in Figure 18. This is in contrast with the Groves, Nickson et al study (2000b) which found that "it appears that larger software development groups typically have more well-defined software development processes". However it may be that this study had too few larger software development groups for this to be tested.

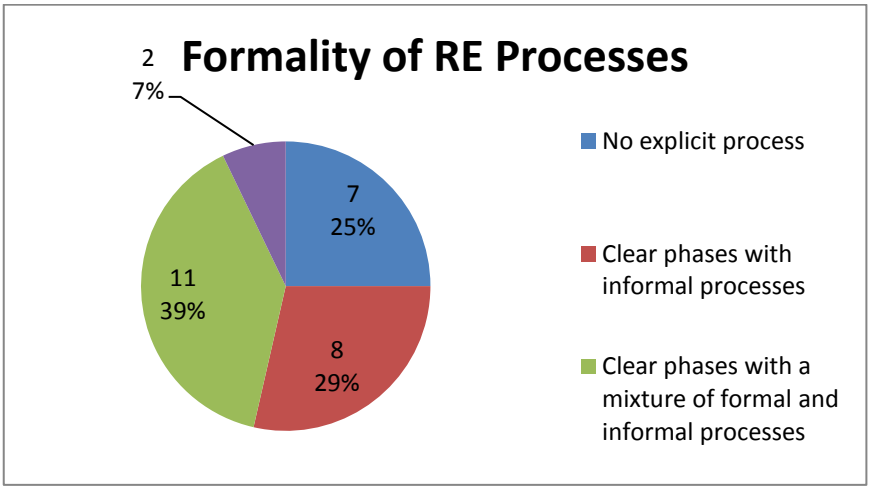

Figure 17 Formality of RE Processes

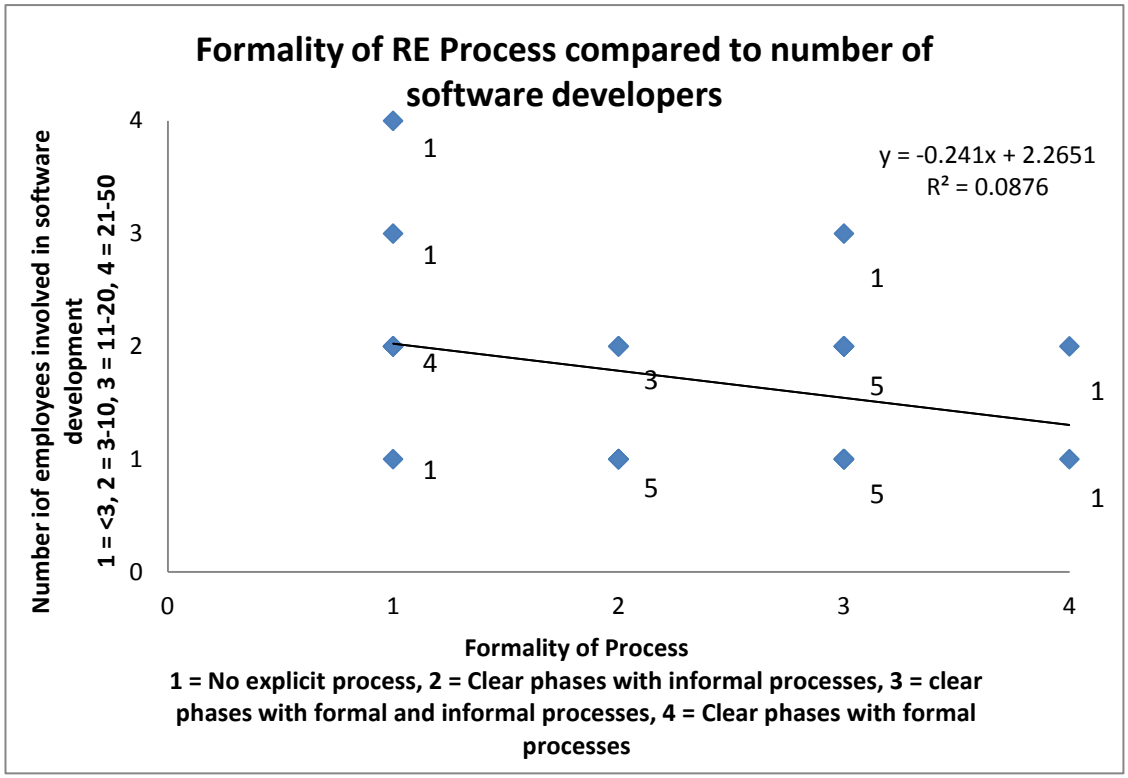

Figure 18 Formality of RE Process compared to number of software developers

4.1.1.14 Formality of Language used in RE Specification Document

This question extends the previous question by looking at the specification document, the main output from the RE process. The results, shown in Figure 19, are better than those reported by Neill and Laplante (2003) who found that once the no-response figures were removed that 60% of their respondents reported that the language used in specifications was informal, 31.5% semi-formal and 8.5% formal.

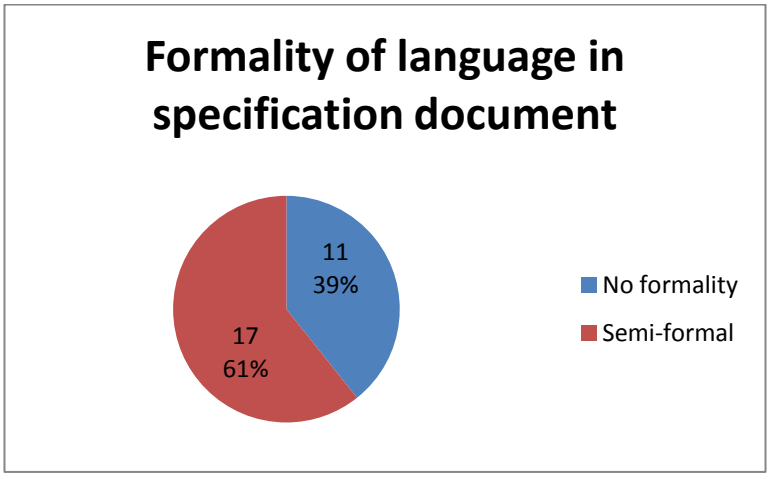

Figure 19 Formality of language in specification document

4.1.1.15 Informal Assessment of RE Process Maturity

The answers from the previous two questions were combined using Table 12 below to give the first informal measure of the RE maturity of the companies based on the degree of formality of the processes followed. The classification is somewhat arbitrary in that the mapping has been specified by the researcher based on their understanding of the original questions and how this classification was made in previous studies. Groves, Nickson et al (2000b) stated in their study that this assessment was "very subjective" because it was reliant on what the interviewer recorded and how this was perceived in the analysis stage of the study.

As none of the respondents said that they used a fully formal language for specification, this response was omitted from the mapping.

The results of this assignment are shown in Figure 20. The comparison of these results with other studies is shown in Table 13.

Additionally, while not providing statistics, Hofmann and Lehner (2001) in their study of fifteen projects, also noted that "only some projects defined their RE process explicitly or tailored an organizational process" and "most stakeholders perceived RE as an ad hoc process".

Mapping to informal RE capability measure		
Formality of Process	**Formality of Language**	**RE Capability Measure**
No explicit process	No formality	No explicit process, No formal language
No explicit process	Semi-formal	No explicit process, No formal language
Clear phases with informal processes	No formality	Clear phases, no formal language
Clear phases with informal processes	Semi-formal	Clear phases, informal specifications
Clear phases with a mixture of formal and informal processes	No formality	Clear phases, informal specifications
Clear phases with a mixture of formal and informal processes	Semi-formal	Clear phases, informal specifications
Clear phases with formal processes	No formality	Clear phases, informal specifications
Clear phases with formal processes	Semi-formal	Formal process, semi-formal notation

Table 12 Mapping to informal RE capability measure

Comparison of Informal RE Capability Results	
Study	**Findings**
Groves, Nickson et al (2000b)	17% No explicit process, No formal language 29% Clear phases, no formal language 25% Clear phases, informal specifications 29% Formal process, semi-formal notation
Hofmann and Lehner (2001)	Only some projects defined their RE process explicitly or tailored an organizational process Most stakeholders perceived RE as an ad hoc process
Nikula, Sajananiemi et al (2000a)	None used formal languages for their specifications, while ten(83%) of the companies reported that semi-formal languages were used either as standard (17%), normally (33%) or discretionary (33%), with only two (17%) saying that they were never used. RE process being defined was standard for four companies (33%), normal for one company (8%), discretionary for three companies (25%) and never for four companies (33%)
Sadraei, Aurum et al (2007)	In most cases , the companies do not have a standard RE process definition In general, RE is generally performed in a particularly ad hoc manner
Verner, Cox et al (2005)	Requirements were gathered using a specific method in 53% of successful projects and 50% of unsuccessful projects
This study	26.9% No explicit process, no formal language 7.7% Clear phases, no formal language 57.7% Clear phases, informal specifications 7.7% Formal process, semi-formal notation

Table 13 Comparison of Informal RE Capability Results

In their discussion on RE process awareness Sadraei, Aurum et al (2007) say that "in most cases , the companies do not have a standard RE process definition", and "in general, RE is generally performed in a particularly ad hoc manner". This is very similar to Hofmann, Lehner et al's findings.

Verner, Cox et al (2005) found in their study of RE and software project success covering 164 projects, that requirements were gathered using a specific method in 53% of successful projects and 50% of unsuccessful projects again indicating a relatively low level of RE process maturity using this measure.

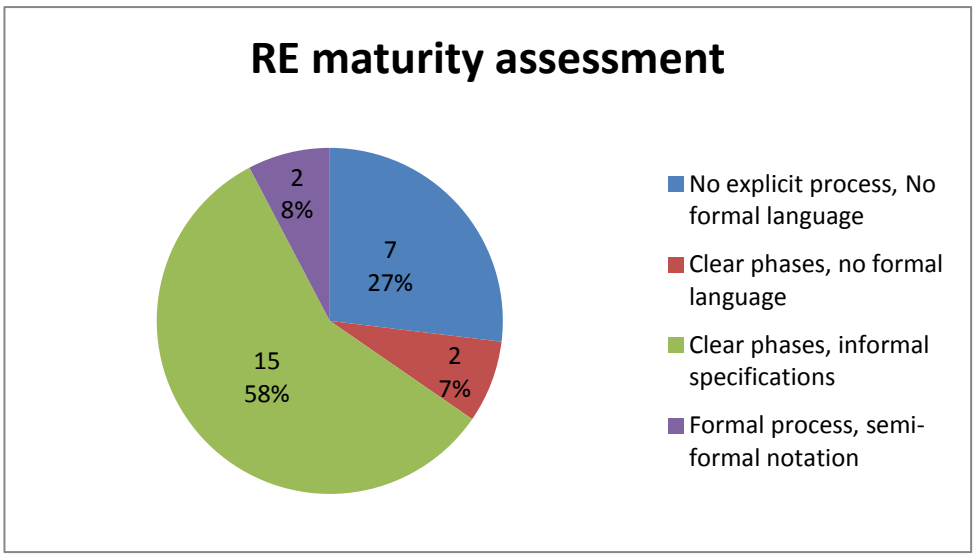

Figure 20 RE maturity assessment

Nikula, Sajananiemi et al (2000a) report that of their twelve companies, none used formal languages for their specifications, while ten of the companies (83%) reported that semi-formal languages were used either as standard (17%), normally (33%) or discretionary (33%), with only two (17%) saying that they were never used. They also reported that the RE process being defined was standard for four companies (33%), normal for one company (8%), discretionary for three companies (25%) and never for four companies (33%). These results show a slightly higher level of maturity overall than the other studies.

Direct comparison is only possible with the Groves, Nickson et al study, where the same classification was used. The results from this study show perhaps a slight improvement in the maturity of RE processes in that in the original study 54% of the respondents were classified as either clear phases with informal specifications, or formal process with semi-formal notation, compared to this study where 65.4% were in this category. However, the original study had more companies in the higher classification 29% compared with 7.7%, and fewer at the lowest level 17% compared with 26.9%. This somewhat negates the previous statement. It is also worth considering the difference in the sizes of the companies included in the two studies. It seems therefore that using this measurement, there is no valid conclusion that can be made as to whether the level of maturity of the RE process in New Zealand has changed in the ten years since the original study.

4.1.1.16 Use of Tools to Support the RE Process

In this part of the survey respondents were asked to state whether they used tools to support the RE process and if so, what tools were used. Of the 28 respondents who answered this question 14 (50%) of them said that no tools were used, while two just specified Microsoft Word. The full list of tools mentioned is shown in Table 14.

List of RE tools used
Visio
UML Toolkits
Eclipse
Prototyping
Enterprise Architect, Visio
Trac, Visual Paradigm's UML modeling
Word
Microsoft Word!
prototyping method
MS Access Relationship diagram (i.e. data model)
Relatively recently using a database/web app to record, track, and prioritise requirements
self developed check lists
Flowchart software
Visio

Table 14 List of RE tools used

These results are similar to those in Phillips, Kemp et al's (2005) study which found that 48.3% of those carrying out requirements gathering used some form of tool to support this activity. The tools used indicate the same range of software development methodologies including structured, prototyping, object-oriented and data-centred identified in the earlier study.

4.1.1.17 Awareness of Other Tools to Support the RE Process

The intention with this question was to find the level of awareness of different RE tools. While 11 of the 28 respondents (39%) said that they were aware of other tools only 4 (14%) were able to name specific tools. The proprietary tools named were Rational (2 respondents), Trac, Together and Doors (1 respondent each). Another two respondents listed UML, while one listed imaging software. Although Groves, Nickson et al (2000b) included this question in their survey, the responses are not included in their analysis, so no comparison can be made with this study.

Of the 14 respondents who are not using any tools, 6 (43%) said that they were aware of other tools but only two (14%) were able to name any. Nikula, Sajaniemi et al's (2000a) study found that of their 12 companies, none used a commercial RM tool, four (33%) recognised

more than one tool, two (17%) recognised one and six (50%) didn't recognise any. It is difficult to make a direct comparison between the studies because the companies in this study were considerably smaller and the respondents were not given a list of tools to select from.

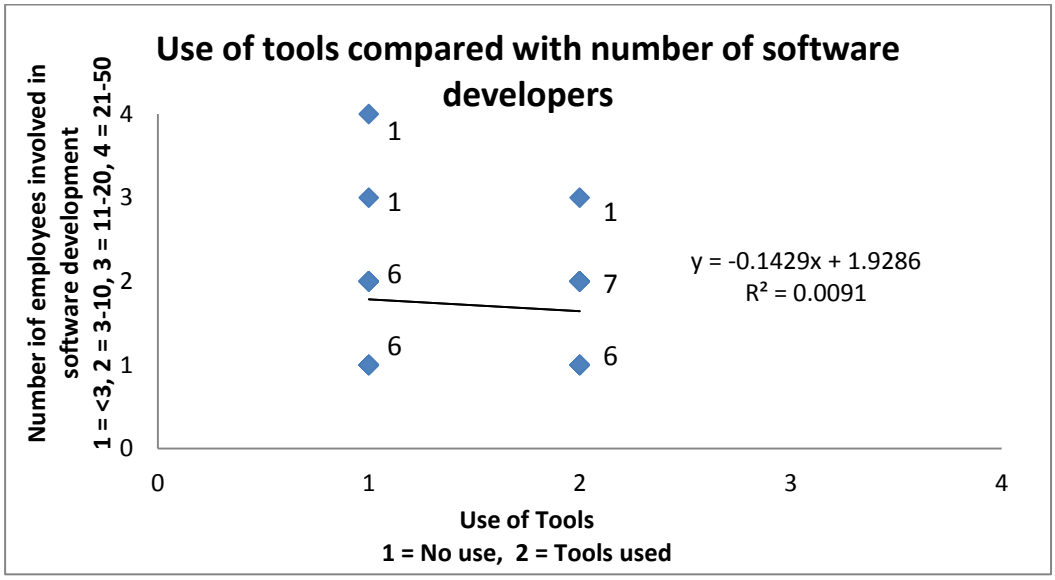

Figure 21 Use of tools compared with number of software developers

Looking at the results of these questions on use and awareness of RE tools it appears that in the New Zealand context little use is being made of RE specific tools in the RE process with only 28% of respondents using them. This could be a reflection of the small size of the companies involved which would make it difficult to cost justify the purchase of such software and maintenance costs of such tools.

Comparison with the size of the software development team as shown in Figure 21 indicates that the size of the software development team has little correlation (R^2 = 0.0091) with the use of RE tools.

4.1.1.18 Requirements Engineering Good Practice Guidelines

In this section of the survey respondents were asked to indicate the level of implementation of the ten guidelines that Sommerville and Sawyer recommend in their book (1997) as the most important RE good practice guidelines. They were given the options of never (scores 0), sometimes (scores 1), normally (scores 2) and compulsory (scores 3). The values were then summed to give a score out of a maximum of 30 points. If a level was not attributed to a guideline a "never" response was assumed.

A summary of the scores is shown in Table 15. The highest score was 24, the average 10.23, the median 10.5 and the standard deviation 5.37. Comparing these results against Nikula, Sajaniemi et al's (2000a) findings this study showed more companies in the mid range with a smaller spread of scores (see Table 16). This indicates an overall higher level of maturity in the New Zealand companies using this particular measure. It is also worth noting that five of the companies (17%) have implemented all ten guidelines at least to some extent. With the highest score being 24 however, using these criteria there is still room for improvement in all the companies.

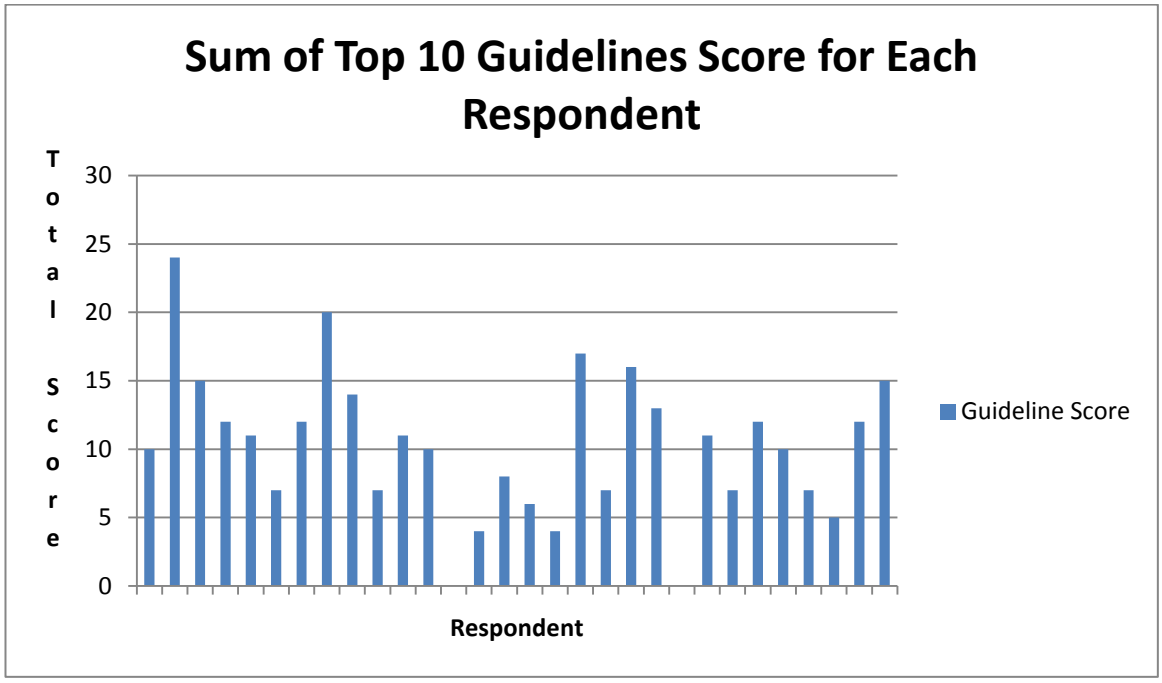

Figure 22 Top 10 guidelines score for each company

Looking at the implementation of individual guidelines it can be seen from Figure 23 that the most frequently implemented guidelines are "Requirements document easy to change" followed by "Language used simply, consistently and concisely", while the least implemented guidelines are "Formal requirements inspections organised", closely followed by "Defined policies for requirements management".

Top 10 Guidelines Summary	
Score	**Number of companies**
4	2
5	1
6	1
7	5
8	1
10	3
11	3
12	4
13	1
14	1
15	2
16	1
17	1
20	1
24	1

Table 15 Summary of scores

Average	8.58	10.23
Median	6.5	10.5
Standard deviation	9.18	5.37

Table 16 Comparison of results

Top 10 Guidelines Comparison		
	Nikula, Sajaniemi et al (2000a)	**This Study**
Highest Score	28	24
Lowest Score	0	4

Table 17 below shows the application of the guidelines in Pareto order for this study and that of Nikula, Sajaniemi et al (2000a). The results show some correlation between the implementations with the main exception being formal inspections being done. This is the least implemented guideline in this study while it ranked third in the earlier study.

Comparison of top 10 guidelines ranking		
Guideline	**Nikula, Sajaniemi et al (2000b) ranking**	**This study ranking**
Standard document structure	1	3
Use simple language	2	2
Formal inspection done	3	10
Document easy to change	4	1
Requirements have a unique id	5	4
Requirements templates used	6	8=
Analysis checklist used	7	5
Conflict resolution planned	8	6
Requirements management policies defined	9	8=
Document validation checklists defined	10	7

Table 17 Comparison of top 10 guidelines ranking

Finally a comparison was made between the RE process maturity stage identified earlier and the guideline total for each company. As can be seen in Figure 24, there is a high correspondence ($R^2 = 0.4474$) between the two scores. This indicates that both methods could provide a rough estimate of the RE capability maturity of an organisation, however the sample size is too small for any definite conclusion. In addition, despite the two methods giving similar results, as no formal measurement of the companies capability has been done the validity of those results cannot be proven.

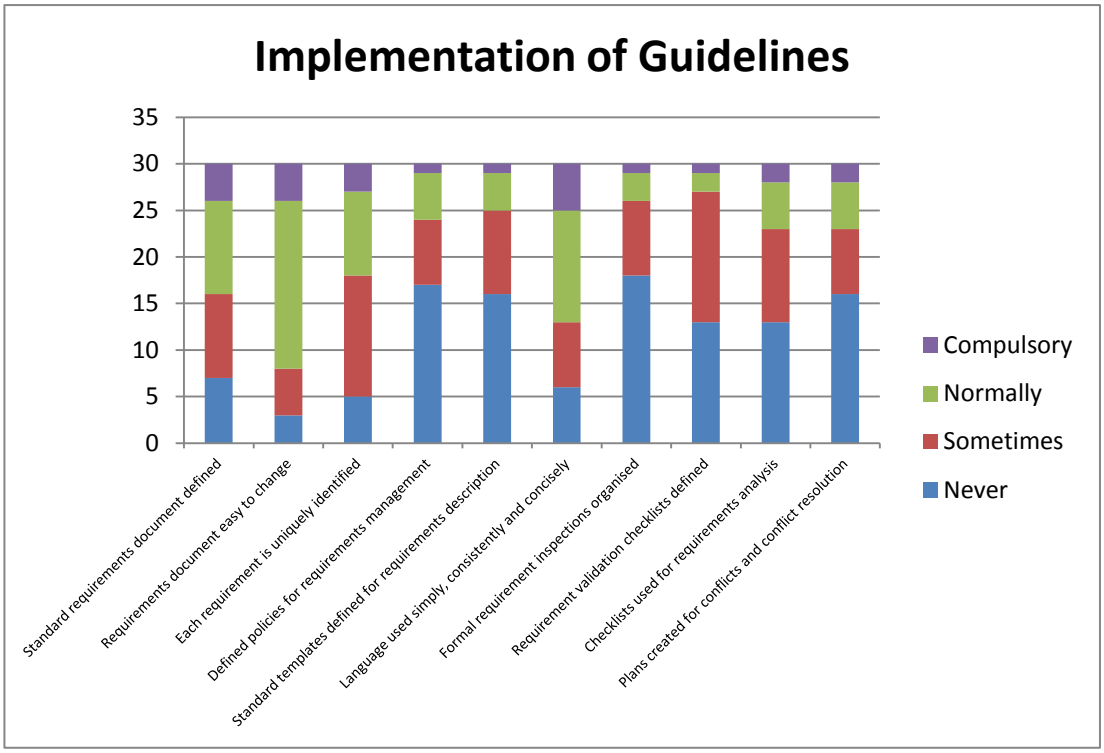

Figure 23 Implementation of Guidelines

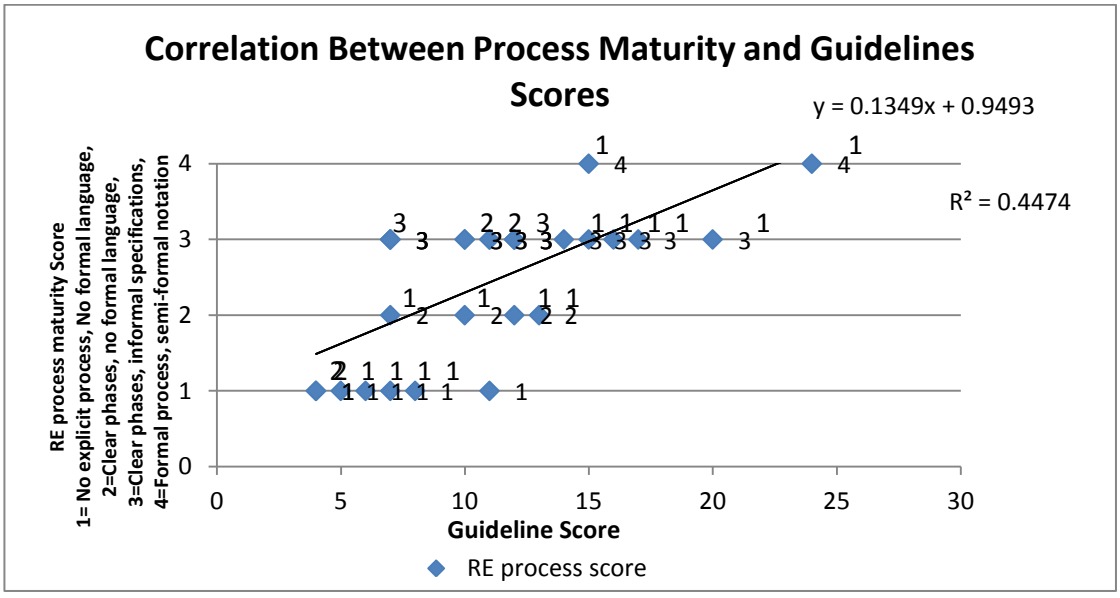

Figure 24 Correlation between RE process maturity and guidelines scores

4.1.1.19 Top Three Issues

Respondents were asked to name the top three issues their organisation faced with respect to software development and requirements engineering. This was an open question aimed at providing the organisations with an opportunity to identify the major issues they faced without being influenced by the researcher.

The answers have been grouped into broad categories to allow the responses to be summarised as shown in Table 18 below. The classification is subjective in that the discretion of the researcher has been used in interpreting the intent of the respondents. The entries are listed in Pareto order with the most frequently mentioned issue at the top of the table. Only those issues mentioned by more than one respondent have been included here.

While the top issue relating to the management of changing requirements is one that is mentioned frequently in previous studies (Hofmann and Lehner, 2001; Nikula, Sajaniemi et al., 2000a), the second in the list is one that is not asked about in overseas studies. This issue relates to the acceptance by the customer of the time, cost and effort involved in establishing the requirements for the software development.

However this issue is mentioned under unsolicited comments in the Groves, Nickson et al (2000a) study where some respondents referred to clients were often being impatient to see results and also that commercial considerations prevented them (the companies) from spending more time on capturing requirements, especially where tenders were involved. This impatience is also referred to by Ralph Young in his foreword to Alexander and Stevens book on writing requirements (2002). Other articles discuss the perceived high cost of RE activities (Ebert and Wieringa, 2005; Morris, Masera, and Wilikens, 1998). The need to educate the client about the benefits of being thorough in the RE process is also mentioned by Zowghi and Coulin (2005).

The individual comments in this classification include "getting people to realise you have to pay for it", "cost to client and perceived benefit", and "convincing customers of its necessity". This indicates that educating the client in the purpose and selling them the benefits of the RE process is a major issue for software development companies in New Zealand. This could be a reflection of the typically small size of the companies surveyed, in that the respondents, mainly directors of the companies, are more likely to be involved in the process of negotiating costs with the customer than would be a software developer or requirements engineer in a large software development company.

Summary of Issues	
Issue	**Number of respondents**
1. Scope creep / changing requirements	9

2. Client acceptance of time/cost/effort spent on requirements before build starts	8
3. Quality of specification (correctness, clarity, completeness)	7
4. Tight Deadlines	3
5. Client signoff of requirements without full understanding or review	3
6. Client understanding/support of the process	3
7. Difficulty in getting information from clients	3
8. Project overruns, time and cost	2
9. Client communication	2
10. Changes in client personnel	2
11. Applying Agile processes	2
12. Prioritising of requirements	2
13. Lack of understanding of business processes	2
14. Lack of agreed process / methodology	2

Table 18 Summary of Issues

In their study Hall, Beecham et al (2002) differentiated between organisational-based and process-based problems. Their three most frequent process based problems were vague initial requirements, undefined requirements process and requirements growth. These items were all of significance to the respondents in this study. In contrast user communication was the fifth most frequent organisational-based problem and the only organisational-based problem they identified that was mentioned in this research.

4.1.1.20 Importance of Specified Issues to the Organisation

This question looked at whether some of the issues that had been identified in earlier studies were of any importance to the companies. The most important issue was communication with the customer about requirements, closely followed by the quality of requirements and managing changing requirements. At the other end of the scale, the least important issue was introduction of requirements management tools, which in turn was only slightly less important than the introduction of more formal specification methods.

These rankings did not correspond fully with the answers to the previous question. This could be because in this question the respondents did not have to come up with the issues themselves, all they were asked to do was to rate the importance of the issues presented to them. So while the results appear to be contradictive, it does not mean that they are wrong, just that they come from different perspectives.

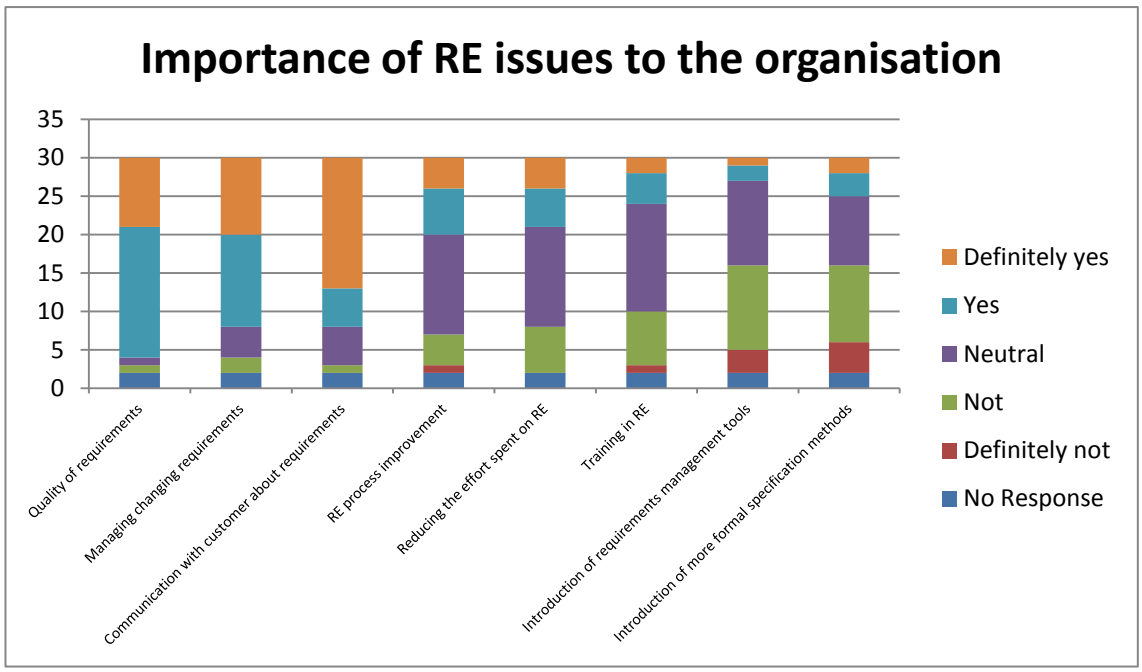

Figure 25 Importance of RE issues to the organisation

Comparing the importance of these issues with the Nikula, Sajaniemi et al (2000a) study (see Table 19), the results are inconclusive. In the original study, RE process improvement and RE tool introduction were ranked second and third, while customer communication ranked fifth under general RE development needs, however in this study process improvement and RE tool introduction were of less importance than customer communication, which was placed third overall. Completeness and change management were the top two issues under requirement development, which correspond to the top two scoring issues, namely quality, which is a broader categorisation than completeness, and managing changing requirements in this study.

Table 19 also includes a comparison to the answers to the previous question asking for the top 3 issues. Not all items identified in this earlier question were included in the issues the respondents were asked to rank in this question, and some licence has been taken in matching the issues for example managing changing requirements has been matched with scope creep.

What is evident is that the top 3 issues identified by the respondents are also of significant importance to those companies surveyed by Nikula, Sajaniemi et al (2000a)

Comparison of Importance of Issues

Issue	Importance Ranking		Top 3 ranking
	Nikula, Sajaniemi et al	***This Study***	***This Study***
Communication with Customer about requirements	6	1	8=
Managing Changing Requirements	2	2	1
Quality of Requirements	1	3	3
RE Process Improvement	3	4	-
Reducing the Effort spent on RE	7	5	2
Training in RE	Not rated	6	-
Introduction of more formal specification methods	4=	7	-
Introduction of requirements management tools	4=	8	-

Table 19 Comparison of Importance of Issues

4.1.2 In-depth Interviews

4.1.2.1 General Comments

Only three out of the nine companies that indicated they would be happy to participate in further research responded to the request for interviews. One of them declined because they were too busy. Another declined to answer the questions, but nevertheless gave their opinion on the value of prototyping, while the third answered the interview questions and returned them. The responses from these latter two companies are discussed in this section.

4.1.2.2 Company 1

This company said that their current client base is limited to medium sized companies with revenue in the region of NZ$10million to $NZ100million. The company is small, having only one or two employees.

In their response they stated that they use prototyping as an alternative to traditional requirements engineering processes and that they have in the past been involved in creating large functional requirements documents, however they do not believe that this is appropriate or cost effective in the New Zealand software development environment in which they operate. The respondent stated that in their view only very large corporations (revenue greater than $NZ100 million) can afford to use traditional methods of software development.

The respondent does not appear to recognise that prototyping is an established method of eliciting requirements and that the company will also be carrying out other RE activities such

as managing changing requirements, prioritising and validating requirements etc during the course of their software development projects.

4.1.2.3 Company 2

This company is larger than Company 1, having between 5 and 20 employees of whom between 3 and 10 are involved in software development and has at least one employee whose primary responsibility is requirements engineering. The titles of those involved in requirements engineering include managing director, software developer and business analyst/project manager. The responsibilities listed included meeting with customers, analysis of customer needs, preparing overview documents, formal requirements investigation with customers (using a variety of methods), documentation of requirements, preparation of project plans with developers and preparation of test plans with customers. The latter two responsibilities are not traditional RE responsibilities, however in the researcher's own New Zealand software development experience the RE person often becomes the main contact with the client throughout the project and in this liaison capacity they may undertake additional project roles.

On the subject of training in RE they stated that this was received as part of a tertiary degree in ICT or from private software development training courses. They also said that there is plenty of material available in terms of literature and training for those willing to invest time in reading and/or study.

With respect to academic training they stated that it is hard to find new graduates who have an interest in requirements engineering or business analysis. They believe that recent graduate programmers who have completed a generalised ICT degree are weak in requirements engineering. A check through the papers offered by New Zealand universities undergraduate degrees bore out this statement, in that while most degrees have a paper on UML, they do not offer a specific RE paper at the undergraduate level, although most of the universities do offer this at the postgraduate level. The respondent said that academic training in RE is critical and that a stronger emphasis should be placed on RE for undergraduates. Real world experience in business is also useful so the requirements engineer has an understanding of the realities involved in the commercial environment. These comments are in line with the opinion voiced by Windbladh (2004) who suggested that computer science education is not producing graduates with RE skills and that graduates do not appear to value the RE process.

They believe that industry training is also useful although it can overly focus on current tools (particularly software) more than principles. This observation could also be applied to the focus on UML in undergraduate degrees.

The major area of concern about RE in their organisation was that they lack sufficient focus on it. As a small business their team need to be multi-skilled and they have found those with technical skills prefer "doing" rather than "documenting". This makes it hard to get sufficient quality and detail in requirements deliverables. Their top three issues were insufficient skilled RE resources with the necessary interest in or understanding of their main customer's business sector, lack of skill in their customers in the RE process and lack of skill/experience in their customers in the testing and acceptance process, together with the customer failing to allocate sufficient resource or time to the project.

The respondent said that they meet around 95% of the requirements as documented and a similar proportion of the business requirements for the project. They said that to achieve this there is an element of clarification, changes or rework and that they would like to be able to identify these earlier in the project. They do use agile processes to assist in early delivery to the customer.

Overall they rated their level of satisfaction with the quality of RE within their organisation at 7 on a scale of 1 to 10, where 10 was extremely satisfied and 1, very dissatisfied. They feel that they still have room for improvement.

They have internal quality standards that specify processes and deliverables. They measure the quality by reviewing engagement with the customer (subjective), quality and completeness of the requirements documentation and database, number of necessary change requests (given the project size), timeliness of delivery and feedback from the customer. They say that these measurements could be made more objective or have defined metrics.

The methodology they use for software development is based on a fixed price quote and assumes a fixed scope project. While they would be prepared to use the agile approach of a fixed price and schedule with variable scope, no clients have taken this option to date.

Once the engagement is confirmed requirements gathering starts. This takes the form of a mixture of one on one meetings with customer staff, larger meetings and document analysis. They use a requirements database and create a software requirement specification document.

Use is made of templates as checklists to ensure that the necessary questions are asked, particularly for non-functional requirements that may affect usage of the software. High level design will begin either in conjunction with this, or immediately afterward. Next the application architecture and data model are designed together with any user interfaces or layout structures. A project plan is developed that takes into account other work and the customer's needs. When this is done a quotation for development is produced. The development phase typically involves a number of fixed duration sprints with deliverable milestones which allow testing and feedback from the customer. The final stage involves acceptance testing and a handover period. This may result in new requirements as the customer finds other ways to use the new software.

The issues they have with this methodology are that these new requirements, while a good thing for customer satisfaction, can impact on other projects. Also managing multiple projects with team members working on more than one project is also challenging. In addition for the RE process to work well they need to get the customers to engage in it.

Their RE process covers all the main RE activities, namely elicitation, analysis and negotiation, validation, description, prioritisation, traceability (this is a relatively new development and not yet fully implemented), and management.

The tools they use to support the RE process are shown in Table 20.

Tools used to support RE process	
Activity	**Tools used**
Elicitation	Whiteboards and paper primarily. Less frequently diagrams and paper prototypes
Analysis and negotiation	Gemini database, clarification of issues by phone, meeting or email
Validation	Feedback of requirements to customer. Use Word, PowerPoint and whiteboard
Description	Gemini plus diagrams generated in Visio
Prioritisation	Done interactively with the client, often using an initial rating prepared by the respondent based on earlier client discussion
Traceability	Gemini database and references incorporated into code
Management	Gemini database

Table 20 Tools used to support RE process

This company completed the additional capability questionnaire. Using the REGPG model (Sawyer, Sommerville et al., 1999) this company scored 61 in the basic guidelines and 37 in the intermediate/advanced guidelines. This put them into level 2 ("repeatable") of the three-

level maturity measurement. The description attached to this is "Repeatable level organisations have defined standards for requirements documents and have introduced policies and procedures for requirements management. They may use tools and methods. Their documents are more likely to be consistently high in quality and to be produced on schedule". Comparing this formal assessment against the two informal assessments included in the survey, this company scored 20 out of maximum of 30 in implementation of the top ten guidelines (Nikula, Sajaniemi et al., 2000b) and was classified into "clear phases with informal specifications" (Groves, Nickson et al., 2000a).

Overall this company showed themselves as reasonably mature in their RE processes.

In the next chapter the findings are summarised and conclusions are drawn. In addition observations are made about the limitations of the research and possible future work.

Chapter V

5.1 Summary

The research aimed to explore the requirements engineering practices of small and medium sized software development and computer consultancy companies in New Zealand and what issues they face. Comparison was to be made with previous New Zealand and international studies, particularly in relation to the implementation of best practices and the RE capability maturity of the companies. To do this it was decided to use an online survey followed up by in-depth interviews.

Email invitations were sent to 217 companies listed in online business directories under the heading of software development and to 184 companies listed in the same directories under the heading of computer consultants. These resulted in 20 responses to the first invitation and a further 10 responses from the second invitation, giving a total of 30 responses in all. Ten companies indicated that they would be prepared to participate in further research. When approached for follow-up interviews two companies responded, one answering the detailed interview questions in full, and one restricting themselves to giving independent comments.

5.1.1 Survey

Over half the companies surveyed had fewer than 5 employees, with 43% saying that less than three of these are primarily engaged in software development. These figures point to the likelihood that many of the companies are either sole traders or partnerships and that the person answering the survey is directly involved in the software development process and carrying out requirements engineering. This means that although it looks from the titles of the respondents that this survey represents a management viewpoint, the possibility of multiple roles filled by one person is very likely. This is borne out by New Zealand Government company statistics that show that 69% of NZ companies have no employees (includes sole traders, while 21% have 1-5 employees, 4% 5-9 employees, 3% 10-19 employees, 2% 20-49 employees and only 1 % 50 or more employees (Statistics New Zealand, 2009).

The number of companies reporting that they have one or more employees whose primary responsibility is RE was 67%. There was a small positive correlation with the number of employees, which might be expected, as smaller companies are more likely to require

employees to use a number of skills, rather than specialise in one area of software development.

While the question relating to whether employees had any formal training in RE was not well phrased, the responses showed that in 25% of the companies who have RE specialists, they have no formal training in the discipline.

The types of software development and the range of supplications developed were very similar to those reported in the earlier New Zealand surveys (Groves, Nickson et al., 2000a; Phillips, Kemp et al., 2005), while project durations overall were shorter than those reported in the Phillips, Kemp et al study. Looking at the number of people involved in a typical project, all of the projects involved less than 10 participants, which suggests that not only are the projects shorter overall but that on average they also involve fewer people. This might be expected given the smaller size of the companies involved.

The figures on RE as a percentage of total project effort reflect the variance that MacDonell and Sheppard (2003) found. However, the average of 18% was similar to the 15% recorded in two overseas studies (Chatzoglou and Macaulay, 1996; Hofmann and Lehner, 2001), but significantly less than the 27% reported by Groves, Nickson et al (2000b).

The figures on the formality of the RE process and the formality of the language used in the RE specification document were inconclusive in respect of showing change against the Groves, Nickson et al (2000b) study as this survey showed increases at both ends of the measure, with fewer companies in the intermediate stages. However this study did indicate a small negative correlation between the formality of the processes and the number of employees involved in software development, which is the opposite of the findings in the original study. This variance could in part be due to the subjective nature of this classification and also to the overall small size of development groups in this study so these findings need to be treated with caution.

Looking at the use and awareness of tools to support the RE process, 50% of respondents said that they used tools, which was a similar number to the Phillips, Kemp et al (2005) study which reported 48% of participants using tools. The list of tools being used indicated the same range of software development methodologies as those identified in the earlier study.

Comparing the use of tools against the number of software developers showed no specific relationship.

Analysing the implementation of Sommerville and Sawyer's (1997) top ten guidelines it was found that in comparison with Nikula, Sajaniemi et al's (2000a) study the New Zealand companies had an overall higher level of maturity using this informal measure. There was a strong correlation found between this informal measure and the other informal measure included in this survey which was based around the degree of formality of the RE process and the degree of formality of language used in the specification document.

When the participants were asked to name the top three issues they face with respect to systems development and requirements engineering, the top of the list was scope creep and changing requirements, closely followed by client acceptance of the time/cost/effort spent on requirements before the build starts and then the quality of the specification in terms of correctness, clarity and completeness receiving 9, 8 and 7 mentions respectively. All other issues raised received a maximum of three mentions. Both of the top 2 issues have been identified in RE literature as common problems. Surprisingly client communication was only mentioned twice.

The final question asked respondents to rate the significance of particular issues to their organisation. Here, in contrast to the previous question, client communication was ranked as the most important, while the quality of requirements and managing changing requirements also ranked highly. Least important were the introduction of requirements management tools and introduction of more formal specification methods.

5.1.2 Interviews

Unfortunately only one participant responded to the request for an interview despite 10 respondents indicating they would be prepared to participate in further research. This person opted to answer the interview questions electronically and return them via email. Another respondent declined to answer the questions, however they wished to extol the benefits their company was finding in using prototyping as an alternative to more formal requirement specification methodologies. From this respondent's perspective this overcame the issue of trying to get the customer to accept the upfront cost, time and effort involved in establishing the requirements.

The participant that did reply to the questions indicated that they felt that academia could do more in respect of teaching requirements engineering to undergraduates and to produce graduates who are interested in this aspect of software development. They also said that requirements engineers need to have an understanding of the realities of the business world.

They said it was difficult to focus on RE in their organisation as being a small business their team needed to be multi-skilled and they have found that their employees prefer building software to documenting requirements. Another issue is that their customers lack experience and skill in the testing and acceptance process.

They were reasonably happy about quality of RE in their organisation and say they meet 95% of the requirements as documented and a similar percentage of the business requirements. They make use of agile processes to assist in early delivery to the customer. While they have internal standards that specify processes and deliverables they do not work to any international standards. They measure the quality of outputs subjectively. Their RE process covers all the main RE activities and they use tools to support all the processes including a requirements database.

This company also completed the questionnaire relating to the implementation of all of Sommerville and Sawyer's good practice guidelines to provide the opportunity to rate the company using the REAIMS model (Sawyer, Sommerville et al., 1997). They received a total score of 61 in the basic and 37 in the intermediate guidelines, placing them well into the intermediate "repeatable" level of capability maturity. In the two informal assessments they scored 20/30 in the top ten guidelines and classified as "clear phases with informal specifications" in the other.

5.2 Learning and Limitations

Some changes to the questions in the survey could have resulted in more specific replies. In light of the number of respondents that identified themselves as director or holding a similar position in the organisation, it would have been useful to establish whether they themselves were directly engaged in requirements engineering. This would have helped in comparison with other surveys where the respondents were primarily software developers. The way it was worded means that some doubt remains as to whether the questions were answered from a manager's perspective rather than a practitioners viewpoint.

The questions around number of employees were taken from previous surveys where respondents were asked to select a group of numbers such as 5-9. In analysing the results it was felt that if respondents had been asked to specify the actual numbers, more detailed analysis would have been possible. For example it may have been possible to calculate the percentage of employees involved in Requirements Engineering having formal training in RE. As it stands only limited conclusions could be made.

The question asking about number of employees involved in RE as a minor part of their job. might have been better phrased as "Number of employees carrying out RE as a minor part of their job". This is because the way it is phrased anyone being consulted during the RE process could have been included in this count, while the researcher wanted to identify people who were carrying out RE activities.

The question about whether any employees have formal training in RE could have been more carefully worded to restrict responses to those who are actually carrying out RE activities. The way the question was actually phrased does not make that distinction.

The original intention was to include questions that would ask about the key RE practices identified by Hoffman and Lehner (2001). Unfortunately, at the time the questionnaire was designed these were overlooked and not included in the survey. These would have provided another lens into the maturity of RE practices in comparison with industry benchmarks.

It might have been useful to ask why respondents were not using RE tools. The responses could then have been compared against the reasons found in Kemps, Phillips et al (2005) study along with other industry studies on the uptake of technology (Kamsties, Hormann et al., 1998; Morris, Masera et al., 1998)

Also, sending through the list of interview questions at the same time as requesting a time for an interview was probably a mistake as it put off most of the respondents. Perhaps a better approach would have been to set up the interviews first, then send through the list of questions.

One sector of requirements engineering practitioners that was not included in this survey are those that are not involved in external software development. There are a considerable number of software development teams that work entirely on in-house developments and

although they were deliberately excluded from this survey, any research that was to fully represent all RE that is carried out in New Zealand would need to include these people.

The range in the size of companies responding to the questionnaire has meant that the results can only be interpreted in the light of small and medium-sized enterprises as none of the companies that responded would be classified as large. Some larger companies would need to be included to provide a more representative slice of the industry as a whole. This is because the larger companies are the bigger employers and therefore are likely to have larger software development teams and possibly be involved in larger or more complex projects.

The number of respondents has also been a factor in limiting the amount of analysis that could be done. A larger, more statistically representative sample would have enabled more advanced analysis to have been undertaken.

These last three limitations are addressed further in the next section which recommends further work.

5.3 Further Research

While this study has given a snapshot of what is happening in small and medium sized software development companies in New Zealand, the number of respondents was small and therefore any conclusions must be treated with caution. In order to provide more validity to these results further investigation is needed.

The first area to be addressed is to increase the sample size. This could be done by sending invitation letters to those companies for whom email addresses were not found. However, while this has the potential to increase the number of respondents, it is likely that the profiles of the companies responding would remain the same. To overcome this, a different method of sampling would be required.

One way of doing this would be to use quota sampling. Using this method the sample population is categorised according to particular variable and specific numbers of respondents are sought to fill the quota for each value that the variable may take (Collis and Hussey, 2003). For this research the variable would be company size and a quota of 10 companies say, representing companies employing less than 5 employees, 10 companies employing 5-19 employees, 10 companies employing 20-49 employee and 10 companies employing 50 or more employees could be sought. This would ensure a sample that is more

representative of the industry as a whole. Companies could be contacted by telephone before being sent the link to participate to confirm company size and willingness to participate.

The next thing that could be changed is to include all companies in the target population, rather than restrict it to those whose primary business is software development. The population of all companies doing business in New Zealand is too large for every company to be contacted so some form of selection, such as systemic sampling where every nth company is contacted (Collis and Hussey, 2003) could be used. This would then allow in-house development teams to be included in the research.

With respect to the information being sought several possible areas for future research have emerged. One would be to investigate further the methodologies followed by the small and mediums sized companies and also follow up on the type of training that the people undertaking RE activities have received. It would also be interesting to survey some of the larger software development companies and to see where the similarities and differences lie. Another area that could be useful to pursue is to find how companies are attempting to overcome the major issues that were identified in this study.

5.4 Conclusions

The aim of the research was to determine some of the factors that affect requirements engineering practice particularly within the small and mediums sized companies that make up the majority of companies developing software in New Zealand and to discover how New Zealand current practice measures up against both formal and informal process maturity measures.

With respect to the first hypothesis "that the capability measures developed overseas can be used effectively to assess New Zealand businesses", insufficient responses were received to allow the testing of formal capability measures. In addition the results from the informal measures were inconclusive.

The second hypothesis was that "requirements engineering practices in New Zealand have changed significantly from those reported in earlier studies". While this study targeted a different population than the earlier New Zealand studies, there appeared to be little difference in the type of software being developed, the methodologies and tools used or the formality of the processes involved. Thus this hypothesis was not proven.

The third hypothesis was that "the issues facing RE practice in New Zealand software development companies are the same as those faced by similar sized overseas companies". This hypothesis has been borne out by the correlation between results from overseas studies and the responses to this survey, both in respect of the rating of the given issues and in the top 3 issues that respondents identified.

The final hypothesis was that "international best practices are not relevant to RE practice in small and medium sized New Zealand software development and computer consultancy companies". The results relating to this hypothesis are inconclusive. Certainly the issues are just as relevant, but the lack of interviews meant that it was not possible to test this.

It is unfortunate that conclusive results were possible for only one of the four hypotheses, namely that the issues faced by New Zealand companies are much the same as those faced by similar sized overseas companies. The first and fourth hypotheses were unable to be tested because companies were not willing to be interviewed. Finally a more representative sample that more closely matched the profiles of the companies involved in the earlier New Zealand Surveys (Groves, Nickson et al., 2000a, 2000b; Kemp, Phillips et al., 2003; Phillips, Kemp et al., 2005) would be needed in order to fully test the hypothesis that the RE practices in New Zealand have significantly changed since those earlier studies. Suggestions as to how these limitations could be overcome are included in the previous section under the topic of further research.

In summary, this research has looked at requirements engineering practice in the software development industry in New Zealand. It has focussed on discovering current practice and made comparisons against previous New Zealand studies and studies overseas that relate to small and medium sized companies. The emphasis has been on attempting to measure the maturity of RE practices and the issues that the industry faces in respect of RE. The major finding is that the issues faced by New Zealand companies are similar to those faced by similar overseas companies.

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Appendices

Appendix A Ethics Application Forms

AUT
AUCKLAND UNIVERSITY OF TECHNOLOGY
TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Auckland University of Technology Ethics Committee

(AUTEC)

EA8

APPLICATION FOR ETHICS APPROVAL FOR LOW ETHICAL RISK RESEARCH PROJECTS

PLEASE READ THE NOTES AT THE END OF THE FORM BEFORE SUBMITTING THIS APPLICATION.

General Information

Project Title

If you will be using a different title in documents to that being used as your working title, please provide both, clearly indicating which title will be used for what purpose.

An Investigation into Requirements Engineering Capability in New Zealand

Applicant Name and Qualifications

When the researcher is a student (including staff who are AUT students), the applicant is the principal supervisor. When the researcher is an AUT staff member undertaking research as part of employment or a staff member undertaking research as part of an external qualification, the applicant is the researcher. Staff should refer to Section 11.4 of Applying for Ethics Approval: Guidelines and Procedures *to check requirements for ethics approval where they are studying at another institution.*

Dr Andrew Connor PHD

Applicant's School/Department/Academic Group/Centre

School of Computing and Mathematical Sciences

Applicant's Faculty

Design and Creative Technology

Student Details

Please complete this section only if the research is being undertaken by a student as part of an AUT qualification.

Student Name(s):

Alison Talbot

Student ID Number(s):

9608889

Completed Qualification(s):

Postgraduate Diploma in Computer and Information Sciences

E-mail address:

alisonmt@ihug.co.nz

School/Department/Academic Group/Centre

School of Computing and Mathematical Sciences

Faculty

Design and Creative Technology

Name of the qualification for which this research is being undertaken:

Master of Computer and Information Sciences

Research Output

Please state whether your research will result in a thesis or dissertation or a research paper or is part of coursework requirements.

Thesis

Details of Other Researchers or Investigators

Please complete this section only if other researchers, investigators or organisations are involved in this project. Please also specify the role any other researcher(s), investigator(s) or organisation(s) will have in the research.

Individual Researcher(s) or Investigator(s)

Please provide the name of each researcher or investigator and the institution in which they research.

Research or Investigator Organisations

Please provide the name of each organisation and the city in which the organisation is located.

Are you applying concurrently to another ethics committee?

If your answer is yes, please provide full details, including the meeting date, and attach copies of the full application and approval letter if it has been approved.

No

Declaration

The information supplied is, to the best of my knowledge and belief, accurate. I have read the current Guidelines, published by the Auckland University of Technology Ethics Committee, and clearly understand my obligations and the rights of the participant, particularly with regard to informed consent.

Signature of Applicant | Date

(*In the case of student applications the signature must be that of the Supervisor)*

Signature of Student | Date

(*If the research is a student project, both the signature of the Supervisor, as the applicant, and the student are required)*

Authorising Signature

Signature of Head	Name of Faculty/Programme/School/Centre	Date

General Project Information

Project Duration

Approximate Start Date of Primary Data Collection

July 2009

Approximate Finish Date of Complete Project

February 2010

Are funds being obtained specifically for this project?

If your answer is yes, then you must complete section C.3 of this Application Form.

No

Types of persons participating as participants

Please indicate clearly every one of the following categories that applies to those participating in your research.

Researcher's students

No

Adults (20 years and above)

Yes

Legal minors (16 to 20 years old)

No

Legal minors (under 16 years old)

No

Members of vulnerable groups

e.g. persons with impairments, limited understanding, etc. If your answer is yes, please provide a full description.

No

Hospital patients

No

Prisoners

No

Does this research involve use of human remains, tissue or body fluids which does not require submission to a Regional Ethics Committee?

e.g. finger pricks, urine samples, etc. (please refer to section 13 of the AUTEC Guidelines). If your answer is yes, please provide full details of all arrangements, including details of agreements for treatment, etc.

No

Does this research involve potentially hazardous substances?

e.g. radioactive materials (please refer to section 15 of the AUTEC Guidelines). If your answer is yes, please provide full details.

No

Research Instruments

Does the research include the use of a written or electronic questionnaire or survey?

If your answer is yes, please attach to this application form a copy of the finalised questionnaire or survey in the format that it will be presented to participants.

Yes

Does the research involve the use of focus groups or interviews?

If the answer is yes, please indicate how the data will be recorded (e.g. audiotape, videotape, note-taking). When interviews or focus groups are being recorded, you will need to make sure there is provision for explicit consent on the Consent Form and attach to this Application Form examples of indicative questions or the full interview or focus group schedule.

Yes, interviews will be recorded on audiotape and written notes may be taken as well.

Does the research involve the use of observation?

If the answer is 'Yes', please attach to this application a copy of the observation protocol that will be used.

No

Does the research involve the use of other research instruments such as performance tests?

If the answer is yes, please attach to this application a copy of the protocols for the instruments and the instruments that will be used to record results.

No

Who will be transcribing or recording the data?

If someone other than the researcher will be transcribing the interview or focus group records or taking the notes, you need to provide a confidentiality agreement with this Application Form.

May use profession transcription service to transcribe tape. Only the researcher will be involved in recording interviews.

How does the design and practice of this research implement each of the three principles of the Treaty of Waitangi (Partnership, Participation and Protection) in the relationships between the researcher and other participants?

Please refer to Section 2.5 of AUTEC's Applying for Ethics Approval: Guidelines and Procedures *(accessible in the Ethics Knowledge Base online via http://www.aut.ac.nz/about/ethics) and to the relevant Frequently Asked Questions section in the Ethics Knowledge Base.*

The research encourages partnership between the researchers and participants in that the intention is to learn about current industry processes followed and tools used. In return for providing this information participants will be offered the findings of my process research. This will enable the participants to learn about how other companies operate both in New Zealand and overseas and may also provide them with information about what is considered best practice. This may assist them in any efforts they undertake in respect of improvement.

Participation is optional and companies can choose not to answer at all, answer the questionnaire only or to be involved in an in-depth interview. Participants need not answer all questions and any incomplete questionnaires will be discarded.

Protection to the participants is offered in terms of confidentiality, using only an id number to identify responses and ensuring that both electronic and paper data is secured in a responsible manner. The website on which the online questionnaire will be hosted is a secure website offering full protection to participants. The only demographic information collected about individuals will be job function.

Does this research target Maori participants?

No

If 'Yes", what consultation has been undertaken when designing the research?

Please identify the group(s) with whom consultation has occurred and provide evidence of their support and any impact this consultation had on the design of the research. Researchers are advised to read the Health Research Council's Guidelines for researchers on health research involving Maori, *available via the Ethics Knowledge Base.*

Does this research target participants of particular cultures or social groups?

Please refer to Section 2.5 of AUTEC's Applying for Ethics Approval: Guidelines and Procedures *(accessible in the Ethics Knowledge Base online via http://www.aut.ac.nz/about/ethics) and to the relevant Frequently Asked Questions section in the Ethics Knowledge Base.*

No

If 'Yes" please identify which cultures or social groups are being targeted and how their cultures or social groups are being considered in the research design.

If your answer to B.9 was 'Yes", what consultation has occurred with these cultures or social groups in the design of the research?

Please identify the group(s) with whom consultation has occurred and provide evidence of their support and any impact this consultation had on the design of the research.

Is there a need for translation or interpreting?

If your answer is 'Yes', please provide copies of any translations with this application and any Confidentiality Agreement required for translators or interpreters.

No

Methodological and Ethical Information

When completing this section, the applicant is advised to consult AUTEC's Applying for Ethics Approval: Guidelines and Procedures, *which is accessible online through http://www.aut.ac.nz/research/ethics .*

Please provide full descriptions of the following aspects of the proposed research:

The aim and background

The aim of the research is twofold. Firstly to explore what the industry identifies as current issues in respect of requirements engineering practice and what tools are being used to support the practice. These findings will be compared against results from previous studies in order to see whether these reflect the earlier findings. The second part of the study will use two formal instruments to measure the maturity of the requirements engineering processes within the companies together with exploring the issues identified in the first part in greater depth. Comparison with results of earlier studies will also be made using this set of information.

The procedure, including the methodology and the methods of data collection and analysis

The study will use both an online questionnaire and follow-up interviews. Together with the questionnaire an introductory letter giving an explanation of the research and providing context to the survey will be developed. The letter will provide the participants with contact details, state the timeline for responses, and when the results are expected to be available. Participants will be asked to sign a consent form and will be given the opportunity of electing to receive a copy of the results of the study.

The questionnaire has been piloted within the School of Computing and Mathematical Sciences. The accompanying introductory letter, consent form and outline interview questions were included in the pilot study.

The details of selected companies will be entered into a separate database and a questionnaire number assigned to them. Once the questionnaire has been finalised, it will be sent to the selected companies. A timeframe of a month will be allowed for return of questionnaires. As they are returned the database containing the company information will be updated with a contact name if it has been supplied, the date the reply received and whether the company wishes to receive a copy of the results and if they are willing to participate in an in-depth interview. If insufficient replies have been received within 6 weeks, follow up calls will be made if possible.

Following on from the questionnaire an outline for semi-structured interviews with those companies that indicate their willingness to participate will be sent to them prior to the interviews so they have the opportunity to prepare their responses. The aim will be for the interviews to take 1-2 hours and the intention is to record the interviews for later analysis. This will ensure that answers are not missed which can happen if the interviewer is writing down the responses. It will also assist in allowing the interview to flow freely as there will be no need for pauses while the response to the question is written down before moving on.

All replies received will be analysed using SPSS or similar statistical analysis software. As stated earlier, only a questionnaire number will be used to identify the respondent in this database.

The number of participants that will be involved, how they will be recruited, how they will be selected from those recruited, any exclusion criteria that will be applied in their recruitment or selection, and how their privacy will be protected.

Business directories will be used to source companies offering system development services. Company Head Office addresses will be used as the primary location of the business. A minimum of 50 companies from each of the five main centres (Auckland, Hamilton, Wellington, Christchurch and Dunedin) will be randomly selected and invited to participate in the study. In addition, the AUT School of Computing and Mathematical Sciences has a research relationship with a number of

companies in the software development field. It is proposed to include all these companies in the survey and those who respond and indicate that they are willing to participate, for in-depth interviews. If more offers are received than the researcher feels able to cope with in the timeline for then research companies will nbe selected randomly by drawing the names out of a hat. Up to 10 in-depth interviews will be done,

Please describe how, the exact location, and for how long the data and/or Consent Forms will be stored, as well as who will have access to them and how they will be destroyed.

If data and/or Consent Forms will be stored somewhere other than AUT, or will be stored for a period other than six years, please provide a justification for this. Please note that data and Consent Forms need to be stored separately.

Data will be encrypted and stored on the AUT network and the online questionnaire will be hosted using the survey software provider's secure website. The consent forms will be stored in a locked filing cabinet on in Dr Andrew Connor's office, School of Computing and Mathematical Sciences. Access to the latter will be only by Dr Connor. All data will be held for seven years and then destroyed.

Funding Details:

Has an application for financial support for this project been (or will be) made to a source external to AUT or is a source external to AUT providing (or will provide) financial support for this project?

No

Has the application been (or will it be) submitted to an AUT Faculty Research Grants Committee or other AUT funding entity?

No

If the answer to C.3.1 or C.3.2 was 'yes', please provide the name of the source, the amount of financial support involved, and clearly explain how the funder/s are involved in the design and management of the research.

Please provide full details about the financial interest, if any, in the outcome of the project of the researchers, investigators or research organisations mentioned in Part A of this application.

Checklist

Please ensure all applicable sections of this form have been completed and all appropriate documentation is attached as incomplete applications will not be considered by AUTEC.

Section A	General Information Completed	√
	Signatures/Declaration Completed	√
Section B	General Project Information Completed	√

Section C	Methodological and Ethical Information Completed	√
Spelling and Grammar Check (please note that a high standard of spelling and grammar is required in documents that are issued with AUTEC approval)		√

Attached Documents (where applicable)

Participant Information Sheet(s)	√
Consent Form(s)	√
Questionnaire(s)	√
Indicative Questions for Interviews or Focus Groups	√
Observation Protocols	
Recording Protocols for Tests	
Advertisement(s)	
Hazardous Substance Management Plan	
Any Confidentiality Agreement(s)	
Other Documentation	

Before submitting this application, please note the following:

- *Incomplete or incorrectly formatted applications will not be considered by AUTEC;*
- *Please check online for the most recent version of this form before submitting your application;*
- *Please do not alter the formatting of this form or delete any sections. If a particular question is not applicable to your research, please state that as your response to that question;*

This form needs to be submitted, along with a completed EA8RA self assessment form and all associated documents as follows:

- *In electronic form;*
- *By 4 pm on the submission date to:*

  The AUTEC Faculty Representative for your Faculty (contact details for the AUTEC Faculty Representatives is available online in the Ethics Knowledge Base, accessible via http://www.aut.ac.nz/about/ethics).

Before the sub-committee meeting date, a signed and printed copy of this application form only needs to have been given to the AUTEC Faculty Representative.

Auckland University of Technology Ethics Committee (AUTEC)

EA8RA

SELF ASSESSMENT OF RESEARCH PROJECTS FOR ETHICS APPROVAL

PLEASE READ THE NOTES AT THE END OF THE FORM BEFORE SUBMITTING THIS APPLICATION.

General Information

Project Title

An Investigation into Requirements Engineering Capability in New Zealand

Applicant Name and Qualifications

When the researcher is a student (including staff who are AUT students), the applicant is the principal supervisor. When the researcher is an AUT staff member undertaking research as part of employment or a staff member undertaking research as part of an external qualification, the applicant is the researcher.

Dr Andrew Connor

Student Name(s)

Please complete this section only if the researcher is a student

Alison Talbot

Assessment of Ethical Risk

The following sections will help assess the risk of your research project causing physical or psychological harm to participants and whether the nature of any harm is minimal and no more than is normally encountered in daily life.
Note: Student researchers are required to review the completed form with their supervisor.

Risk of Harm

Does your project involve situations in which the researcher may be at risk of harm?

~~Yes~~ / No

Does your project involve use of a questionnaire or interview or other research process, whether or not it is anonymous, which might reasonably be expected to cause discomfort, embarrassment, anxiety or psychological or spiritual harm to any or some participants?

~~Yes~~ / No

Does your project involve processes that are potentially disadvantageous to a person or group, such as the collection of information, images etc. which may expose that person/group to discrimination or criticism?

~~Yes~~ / No

Does your project involve collection of information of illegal behaviour(s) gained during the research which could place the participants at current or future risk of criminal or civil liability or be damaging to their financial standing, employability, professional or personal relationships?

~~Yes~~ / No

Does your project involve any form of physically invasive procedure on volunteer participants, such as the collection of blood, body fluid or tissue samples, exercise regimes, physical restraint or physical examination?

~~Yes~~ / No

Does your project involve the administration of any form of drug, medicine (other than in the course of standard medical procedure), or placebo?

~~Yes~~ / No

Does your project involve physical pain, beyond mild discomfort?

~~Yes~~ / No

Does your project involve the intentional recruitment of participants who are staff or students of AUT. (Note: section 6.1 of AUTEC's Applying for Ethics: Guidelines and Procedures provides an exception for audit or evaluation purposes only)?

~~Yes~~ / No

Does your project involve any AUT teaching which involves the participation of AUT students for the demonstration of procedures or phenomena which have a potential for harm?

~~Yes~~ / No

Does your project involve participants who are in any sort of dependent relationship to the researchers?

~~Yes~~ / No

Informed and Voluntary Consent

Does your project involve the use of oral consent of participants rather than written consent?

~~Yes~~ / No

Does your project involve participants who are unable to give informed consent?

~~Yes~~ / No

Does your project involve your (or your supervisor's) own students as participants (Note: section 6.1 of AUTEC's Applying for Ethics: Guidelines and Procedures provides an exception for audit or evaluation purposes only)?

~~Yes~~ / No

Does your project involve the participation of children aged 8 years or younger?

~~Yes~~ / No

Does your project involve the participation of children aged sixteen years or younger where parental consent is not being sought?

~~Yes~~ / No

Does your project involve participants who are in a dependent situation, such as people with a disability, or residents of a hospital, nursing home or prison or patients highly dependent on medical care?

~~Yes~~ / No

Does your project involve participants who are vulnerable (e.g. the elderly, prisoners, persons who have suffered abuse, persons who are not competent in English, new immigrants)?

~~Yes~~ / No

Does your project involve the use of previously collected information or biological samples for which there was no explicit consent for this research?

~~Yes~~ / No

Privacy or Confidentiality

Does your project involve any research about organisational practices where information of a personal or sensitive nature may be collected and where participants may be identified?

~~Yes~~ / No

Deception

Does your project involve deception of the participants, including concealment and covert observations except in a public place?

~~Yes~~ / No

Conflict of Interest

Does your project involve a conflict of interest situation for the researcher (where the researcher has more than one role or interest e.g. teacher/researcher, treatment provider/researcher, employer/researcher? (Financial interests in research outcomes, sponsorship, etc. should be declared here)

~~Yes~~ / No

Payment to Participants

Does your project involve payments or other financial inducements (other than koha, reasonable reimbursement of travel expenses or time, or entry into a modest prize draw) to participants?

~~Yes~~ / No

Procedural Issues

Does your project involve a requirement by an outside organisation (e.g. a funding organisation or a journal in which you wish to publish) for AUTEC approval?

~~Yes~~ / No

Other Issues

Does your project involve any ethical issues which may mean that the research is not low risk, other than those mentioned above?

~~Yes~~ / No

If your answer was yes, please briefly describe the issues involved.

Applying for Ethics Approval

If your answer to ALL the above questions is 'No'

Please complete the EA8 application form for low ethical risk approvals and send it together with this completed self-assessment to your AUTEC Faculty Representative. If you work outside a faculty, please send them to the Ethics Coordinator who will forward them to the AUTEC Faculty Representative in the most appropriate faculty for the subject matter of the research.

If your answer to at least one of the above questions is 'Yes'

If you have answered 'Yes' to one or more of the above questions, you will normally need to submit a full EA1 application form to AUTEC, through the Ethics Coordinator. However, if you consider that the reasons why you responded 'yes' do not take the research out of the low ethical risk category, you may wish to consult your AUTEC faculty representative or the Ethics Coordinator before submitting a full application,.

Before submitting this application, please note the following:

- *Incomplete or incorrectly formatted applications will not be considered by AUTEC;*
- *Please check online for the most recent version of this form before submitting your application;*
- *Please do not alter the formatting of this form or delete any sections. A response is required for each question in part B.*

This form needs to be submitted, along with a completed EA8 application form and all associated documents as follows:

- *In electronic form;*
- *By 4 pm on the submission date to:*

The AUTEC Faculty Representative for your Faculty (contact details for the AUTEC Faculty Representatives is available online in the Ethics Knowledge Base, accessible via http://www.aut.ac.nz/about/e

Appendix B Online Survey

Page 1 Background Information

An Investigation into Requirements Engineering Practice in New Zealand

By completing this survey you are indicating your consent to participate in this research.

You can exit this survey at any time by pressing the "Exit Survey" button. If you exit before completing the survey, any information you have provided will be excluded.

This section provides information about the size of your company, the number of people involved in software development and the types of projects undertaken

1. What is your job title?

2. How many people are employed in your organisation in New Zealand?

- ○ <5
- ○ 5-20
- ○ 21-50
- ○ 51-150
- ○ >150

3. How many people including contractors are primarily engaged in software development/maintenance?

- ○ <3
- ○ 3-10

- 11-20
- 21-50
- >50

4. How many people including contractors are primarily engaged in requirements engineering?

- 0
- 1-2
- 3-5
- 6-10
- 11-30
- >30

5. How many people including contractors are involved in requirements engineering as a minor part of their job function?

- 0
- 1-2
- 3-10
- 11-20
- 21-50
- >50

6. Do any of the people carrying out requirements engineering activities have any formal training in requirements engineering?

- None of the people
- Some of the people
- All of the people

7. What type of software development does your company primarily undertake?

- One off
- Customised
- Package

8. How often are any of following of application types developed in your organisation? Please indicate all that apply

Never Sometimes Often Always

Management Information systems (e.g. decision support)

Transaction processing systems (e.g. payroll, POS, accounting, inventory)

Real time applications (e.g. process control, manufacturing)

E-commerce/web applications

Embedded Systems (e.g. software running in consumer devices or vehicles)

Systems software (e.g. telecommunications software

Other

Please specify

9. What would be the typical length of software development projects undertaken in your organisation?

- <3 months
- 3-6 months
- 7-12 months
- 1-3 years
- >3 years

10. Typically, how many of your employees (including contractors) would be involved in a software development project?

- <3
- 3-9
- 10-20
- >20

Page 2 Requirements Engineering Practice

You can exit this survey at any time by pressing the "Exit Survey" button. If you exit before completing the survey, any information you have provided will be excluded.

This section covers how requirements engineering is carried out in your organisation and how it relates to the overall process of software development

11. On average, what percentage of the total project effort is spent in requirements engineering?

Percentage Project effort

0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55
56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100		

12. How formal is the requirements engineering process in your organisation?

- No explicit process
- Clear phases with informal processes
- Clear phases with a mixture of formal and informal processes
- Clear phases with formal processes

13. Is there any formality in the language used in requirements specifications?

Semi-formal includes use of pseudo-code, diagrams including UML diagrams, etc

Formal languages include Z, B, VDM, etc

- No formality
- Semi-formal
- Fully formal

14. Do you use any tools to support your requirements engineering processes?

- Yes
- No

If yes, please list

15. Apart from those you have listed above, are you aware of any tools that support the requirements engineering process?

Yes

No

If yes, please list those you are aware of

16. Please indicate which response best describes your organisation's implementation of requirements engineering practices.

	Never	Sometimes	Normally	Compulsory
Standard requirements document defined				
Requirements document easy to change				
Each requirement is uniquely identified				
Defined policies for requirements management				
Standard templates defined for requirements description				
Language used simply, consistently and concisely				
Formal requirement inspections organised				
Requirement validation checklists defined				
Checklists used for requirements analysis				
Plans created for conflicts and conflict resolution				

17. What are the top 3 issues facing your organisation with respect to software development and requirements engineering?

Issue 1

Issue 2

Issue 3

18. Which of the following requirements engineering issues are important to your organisation?

Definitely not	Not	Neutral	Yes	Definitely yes

Quality of requirements (correctness, clarity, completeness etc)

Managing changing requirements

Communication with customer about requirements

Requirements engineering process improvement

Reducing the effort spent on requirements Engineering

Training in requirements engineering

Introduction of requirements management tools

Introduction of more formal specification methods

Page 3 Final

Thank you for completing this survey

If you are interested in participating in further research by taking part in an interview which will take approximately one hour of your time

Or

If you would like to receive a copy of the results from this research

Please click on the hyperlink below. This link will allow you to enter your contact details so that they can be kept independent of your answers to the questions thus ensuring that your answers will remain anonymous.

Click here to enter contact details

Survey 2 – Contact Details

Page 1

Please enter your contact details. This information will be held and accessed separately. No link will be made with your answers to the questions in the main survey, ensuring that your responses will remain anonymous.

1. Would you be interested in participating in further research?

- Yes
- No

2. Would you like to receive a copy of the results from this research?

- Yes
- No

3. Please enter your contact details

Name:
Company:
Address:
Address 2:
City/Town:
Postal Code:
Email address:
Phone Number:

Page 2

Thank you for completing this survey and registering your interest in taking part in further research and/or requesting a copy of the results.

Appendix C Interview Questions

08/02/2010

INVESTIGATION INTO REQUIREMENTS ENGINEERING CAPABILITY IN NEW ZEALAND

INTERVIEW QUESTIONS

08/02/2010

1. What are the job title(s) of the person(s) primarily responsible for requirements engineering in your organisation?
   Click here to enter text.
2. What are their responsibilities?
   Click here to enter text.
3. Please provide details of any, formal education and/or training have they had in requirements engineering? (course name, length and provider – industry, PTE or Tertiary institution).
   Click here to enter text.
4. Do you consider there is sufficient literature and training available for requirements engineers?
   Click here to enter text.
5. What additional information and training could be provided to assist?
   Click here to enter text.
6. What value do you place on industry training?
   Click here to enter text.
7. What value do you place on academic training?
   Click here to enter text.
8. If university graduates had stronger education in Requirements Engineering, would this be of benefit to your business and why?
   Click here to enter text.
9. What are the main areas of concern you have about requirements engineering in your organisation
   Click here to enter text.
10. Can you expand on your top three issues and the impact they have on your business
    Click here to enter text.
11. On a scale of 1-10, where 1 is extremely dissatisfied and 10 is extremely satisfied, how satisfied are you with the quality of requirements engineering in your organisation?
    Click here to enter text.

08/02/2010

12. What proportion of your projects meet the requirements as documented?
    Click here to enter text.
13. What proportion of your projects meet the business requirements for the project?
    Click here to enter text.
14. What, if any, quality standards that you are required to meet?
    Click here to enter text.
15. How would you measure the quality of your requirements engineering activities?
    Click here to enter text.
16. Please describe the methodology do you follow for software development.
    Click here to enter text.
17. What issues do you have with it?
    Click here to enter text.
18. Please describe the methodology you follow for requirements engineering.
    Click here to enter text.
19. What issues do you have with it?
    Click here to enter text.
20. Does it cover each of the main activities?
    a. Elicitation Yes☐ No☐
    b. Analysis and negotiation Yes☐ No☐
    c. Validation Yes☐ No☐
    d. Description Yes☐ No☐
    e. Prioritisation Yes☐ No☐
    f. Traceability Yes☐ No☐
    g. Management Yes☐ No☐

08/02/2010

21. What, if any, tools do you use to support the following requirements engineering activities?
    a. Elicitation
    Click here to enter text.
    b. Analysis and negotiation
    Click here to enter text.
    c. Validation
    Click here to enter text.
    d. Description
    Click here to enter text.
    e. Prioritisation
    Click here to enter text.
    f. Traceability
    Click here to enter text.
    g. Management
    Click here to enter text.
22. Do you have any further comments about Requirements Engineering in your organisation or in the software development industry?
    Click here to enter text.

Thank you for your participation

If you are interested in receiving a Requirements Engineering Capability Assessment for your company would you please complete the attached additional questionnaire.

The outcome of a capability measurement is that a company is graded on a scale that represents the maturity of its processes, or in other words, how well advanced the organisation is in terms of consistency and completeness, and seeking to continually improve its performance in delivering quality software. It will also highlight possible areas for improvement.

Appendix D Capability Assessment Questionnaire

08/02/2010

Capability Assessment Questionnaire

For each of the Requirements Engineering activities below please select the response that best describes your organisation's implementation of that activity. In order for an assessment to be made all questions should be answered. Use the "Not Applicable" option if you consider the activity is not relevant to your organisation. When you have finished please save the document and return via email.

Organisation: Click here to enter text.

Guideline	Applicability	Implementation
Basic Guidelines		
Define a standard document structure	Requirements Document	Choose an item.
Explain how to use this document	Requirements Document	Choose an item.
Include a summary of the requirements	Requirements Document	Choose an item.
Make a business case for the system	Requirements Document	Choose an item.
Define specialised terms	Requirements Document	Choose an item.
Lay out the document for readability	Requirements Document	Choose an item.
Help readers find information	Requirements Document	Choose an item.
Make the document easy to change	Requirements Document	Choose an item.
Assess system feasibility	Requirement Elicitation	Choose an item.
Be sensitive to organisational and political considerations	Requirement Elicitation	Choose an item.
Identify and consult system stakeholders	Requirement Elicitation	Choose an item.
Record requirements sources	Requirement Elicitation	Choose an item.
Define the system's operating	Requirement Elicitation	Choose an item.

environment		
Use business concerns to drive requirements elicitation	Requirement Elicitation	Choose an item.
Define system boundaries	Analysis and Negotiation	Choose an item.
Use checklists for requirements analysis	Analysis and Negotiation	Choose an item.
Provide software to support negotiations	Analysis and Negotiation	Choose an item.
Plan for conflicts and conflict resolution	Analysis and Negotiation	Choose an item.
Prioritise requirements	Analysis and Negotiation	Choose an item.
Define standard templates for describing requirements	Describing Requirements	Choose an item.
Use language simply and concisely	Describing Requirements	Choose an item.
Use diagrams appropriately	Describing Requirements	Choose an item.
Supplement natural language with other descriptions of requirements	Describing Requirements	Choose an item.
Develop complementary system modelling	System Modelling	Choose an item.
Model the system's environment	System Modelling	Choose an item.
Model the system architecture	System Modelling	Choose an item.
Check that the requirements document meets your standards	Requirement Validation	Choose an item.
Organise formal requirements inspections	Requirement Validation	Choose an item.
Use multi-disciplinary teams to review requirements	Requirement Validation	Choose an item.
Define validation checklists	Requirement Validation	Choose an item.
Uniquely identify each requirement	Requirement Management	Choose an item.
Define policies for requirements management	Requirement Management	Choose an item.
Define traceability policies	Requirement Management	Choose an item.
Maintain a traceability manual	Requirement Management	Choose an item.
Create safety requirements checklists	Critical systems	Choose an item.

Involve external reviewers in the validation process	Critical systems	Choose an item.
Intermediate Guidelines		Choose an item.
Look for domain constraints	Requirement Elicitation	Choose an item.
Record requirements rationale	Requirement Elicitation	Choose an item.
Collect requirements from multiple viewpoints	Requirement Elicitation	Choose an item.
Prototype poorly understood requirements	Requirement Elicitation	Choose an item.
Use Scenarios to elicit requirements	Requirement Elicitation	Choose an item.
Define operational processes	Requirement Elicitation	Choose an item.
Classify requirements using a multi-dimensional approach	Analysis and Negotiation	Choose an item.
Use interaction matrices to find conflicts and overlaps	Analysis and Negotiation	Choose an item.
Specify requirements quantitatively	Describing Requirements	Choose an item.
Use structured methods for system modelling	System Modelling	Choose an item.
Use a data dictionary	System Modelling	Choose an item.
Document the links between stakeholder requirements and system models	System Modelling	Choose an item.
Use prototyping to animate requirements	Requirement Validation	Choose an item.
Write a draft user manual	Requirement Validation	Choose an item.
Propose requirements test cases	Requirement Validation	Choose an item.
Use a database to manage requirements	Requirement Management	Choose an item.
Define change management policies	Requirement Management	Choose an item.
Identify global system requirements	Requirement Management	Choose an item.
Identify and analyse hazards	Critical systems	Choose an item.
Derive safety requirements from hazard analysis	Critical systems	Choose an item.

Cross-check operational and functional requirements against safety requirements	Critical systems	Choose an item.
Advanced Guidelines		Choose an item.
Reuse requirements	Requirement Elicitation	Choose an item.
Assess requirements risks	Analysis and Negotiation	Choose an item.
Paraphrase system models	Requirement Validation	Choose an item.
Identify volatile requirements	Requirement Management	Choose an item.
Record rejected requirements	Requirement Management	Choose an item.
Specify systems using formal specification	Critical systems	Choose an item.
Collect incident experience	Critical systems	Choose an item.
Learn from incident experience	Critical systems	Choose an item.
Establish an organisational safety culture	Critical systems	Choose an item.

Appendix E Participant Information Sheet

Participant Information Sheet

Project Title

An Investigation into Requirements Engineering Practice in New Zealand

Invitation

My name is Alison Talbot and I am a Masters student at Auckland University of Technology (AUT). I am undertaking research study to discover how Requirements Engineering is practised in New Zealand.

Participation in this study is completely voluntary and you can withdraw from this study at any time, without explanation. You may also withdraw retrospectively any consent given, and to require that any data gathered about your company be destroyed.

Before you decide it is important that you understand why the research is being done and what it will involve. Please take as much time as you need to read this information carefully.

What is the purpose of this research?

The aim is to determine some of the issues that affect requirements engineering practice and discover whether New Zealand current practice encompasses application of current theory particularly that relating to process improvement. This research builds on earlier surveys in New Zealand.

How was I chosen for this invitation?

You were chosen because your company is listed in the on-line UBD directory under the heading of software development.

What will happen in this research?

You will be asked to complete a short on-line survey that includes questions about your company and the processes you follow in performing Requirements Engineering tasks. This should take only 10 to 15 minutes to complete. You will then be asked if you wish to participate in further research. If you consent you will be contacted so that an interview time can be arranged and a list of indicative questions sent to you. The interview will take about an hour and will be recorded on audiotape.

What are the discomforts and risks?

There are no known risks in participating. If you feel discomfort answering the on-line survey because your colleagues can view your screen a paper copy can be provided.

What are the benefits?

The results of the research will provide you with the opportunity to evaluate your company's practices against other companies in the industry in New Zealand and in terms of the implementation of what is considered industry best practice.

How will my privacy be protected?

Any data collected in this research study will remain confidential. No personal information will be collected. No information that could lead to individual companies being identified will be published.

What opportunity do I have to consider this invitation?

I understand that it requires time for you to consider and decide whether to participate. I would appreciate if you could complete the survey within two weeks of the receipt of this invitation.

How do I agree to participate in this research?

By completing the survey you are indicating your consent to participate in this research.

Will I receive feedback on the results of this research?

At the end of the survey you will be asked if you wish to receive a copy of the results. If you request this they will be sent to you. This is likely to be early in 2010.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr. Andy Connor, andrew.connor@aut.ac.nz and Tel: +64 9 921 9999 extension 5211,address: Software Engineering Research Lab, Private Bag 92006, Auckland 1020, New Zealand.

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, madeline.banda@aut.ac.nz , 921 9999 extension 8044.

Whom do I contact for further information about this research?

Researcher Contact Details: Alison Talbot, email: alital66@aut.ac.nz , tel: +64 9 473 7110, address: Software Engineering Research Lab, Private Bag 92006, Auckland 1020, New Zealand.

Approved by the Auckland University of Technology Ethics Committee on 22/10/2009, AUTEC Reference number 09/217.

Appendix F Email Invitation

From: Alison Talbot [alisonmt@ihug.co.nz]

Sent: Tuesday, 24 November 2009 7:21 p.m.

To:

Subject: Requirements Engineering Survey

Attachments: Participant Information.pdf

Project Title

An Investigation into Requirements Engineering Practice in New Zealand

Invitation

My name is Alison Talbot and I am a Masters student at Auckland University of Technology (AUT) School of Computing and Mathematical Sciences and am currently undertaking research study to discover how Requirements Engineering is practised in New Zealand.

What is the purpose of this research?

The aim is to determine some of the issues that affect requirements engineering practice and discover whether New Zealand current practice encompasses application of current theory particularly that relating to process improvement. This research builds on earlier surveys in New Zealand.

What benefit will I receive from participating in this research?

You can choose to receive a copy of the research results which will provide information on how other companies undertake requirements engineering and what they consider to be the main issues facing the industry today.

What is Requirements Engineering?

The term requirements engineering is defined as "covering all the activities involved in discovering, documenting and maintaining a set of requirements for a computer-based system". In other words finding out what the software you are going to

develop has to do. Sometimes this is done by the client, but often it is done as part of the software development. So if you do any of these activities, I would be grateful for your input to the survey.

How was I chosen for this invitation?

You were chosen because your company is listed in the on-line UBD directory under the heading of computer consultants.

What will happen in this research?

You will be asked to complete a short on-line survey that includes questions about your company and the processes you follow in performing Requirements Engineering tasks. This should take only 10 to 15 minutes to complete. You will then be asked if you wish to participate in further research. If you consent you will be asked to provide contact information and then contacted so that an interview time can be arranged and a list of indicative questions sent to you. The interview will take about an hour and will be recorded on audiotape.

Will my answers be anonymous?

The survey has been set up so that all answers are anonymous and there is no link (including IP address) back to either the computer on which the survey is completed or your company. If you ask for a copy of the results or agree to take part in further research your contact details will be sent to me independently of your survey response.

What do I do to take part?

Please click on the link below and the survey will open

http://www.surveymonkey.com/s.aspx?sm=bth5AoQ3_2fyV_2fbQ3NwE5UwQ_3d_3d

Thank you for your time

Alison Talbot

Appendix G Tabulated Survey Responses

The following tables show the replies received to survey questions. The full 30 responses are shown for all questions, although respondents 13 and 22 failed to complete the survey.

DEMOGRAPHIC INFORMATION						
No	**Job Title**	**Number of employees in New Zealand**	**Number primarily engaged in software development**	**Number primarily engaged in RE**	**Number involved in RE as a minor part of their job**	**Any employees with formal training in RE**
1	Director	5-20	<3	3-5	11-20	Some of the people
2	Director	<5	<3	1-2	0	Some of the people
3	Managing Director	5-20	3-10	3-5	1-2	All of the people
4	Managing Director	<5	<3	0	1-2	None of the people
5	Managing Director	<5	<3	0	1-2	None of the people
6	top Dog :-)	<5	<3	1-2	0	Some of the people
7	Director of Technology	5-20	3-10	3-5	3-10	Some of the people
8	Managing Director	<5	<3	1-2	1-2	All of the people
9	Director	<5	<3	1-2	1-2	All of the people
10	Managing Director	5-20	11-20	1-2	3-10	Some of the people
11	Managing Director	5-20	3-10	1-2	0	Some of the people
12	director / software developer	<5	<3	1-2	0	Some of the people
13	Managing director	5-20	3-10	1-2	1-2	None of the people
14	CTO	<5	3-10	0	3-10	None of the people
15	Managing Director	<5	3-10	0	0	None of the people
16	Business Systems Analyst	5-20	3-10	1-2	3-10	Some of the people
17	Contract Programmer	21-50	21-50	0	11-20	Some of the people
18	Director	<5	3-10	1-2	1-2	Some of the people
19	Technical Director	5-20	3-10	1-2	1-2	None of the people
20	Software Developer	5-20	3-10	1-2	1-2	Some of the people
21	director	5-20	3-10	1-2	1-2	None of the people
22	Analyst Programmer/Director	<5	<3	0	1-2	None of the people
23	CEO	<5	<3	0	1-2	All of the people
24	Managing Director	<5	<3	0	1-2	None of the people
25	Manager	5-20	3-10	1-2	3-10	Some of the people
26	Director	<5	<3	0	1-2	All of the people
27	Chief Automation Officer	<5	3-10	1-2	1-2	None of the people
28	Senior Analyst/Programmer	21-50	11-20	0	0	Some of the people
29	IT Manager	<5	<3	1-2	1-2	None of the people
30	Owner	5-20	3-10	1-2	1-2	Some of the people

Table 21 Demographic Information

TYPES OF SOFTWARE									
No	**Type of Software Development**	**Application Types**							
		Management Information systems	**Transaction processing systems**	**Real time applications**	**E-commerce / web applications**	**Embedded Systems**	**Systems software**	**Other**	**Please specify**
1	Customised	Often	Sometimes	Sometimes	Often	Never	Sometimes	Sometimes	Server Technologies
2	Customised	Sometimes	Sometimes	Often	Always	Sometimes	Never	Never	
3	One off	Sometimes	Sometimes	Sometimes	Sometimes	Often	Never		
4	Package	Never	Never	Never	Never	Never	Never	Always	Engineering Software Develepment
5	One off	Never	Never	Never	Never	Never	Never	Sometimes	Scientific applications or integration of applications
6	One off	Sometimes	Sometimes	Never	Always	Never	Never	Never	
7	Package	Always	Often	Always	Always	Always	Always	Always	
8	Customised	Often	Often	Sometimes	Often	Never	Never	Sometimes	
9	One off	Often	Often	Sometimes	Always	Sometimes	Sometimes	Often	
10	Customised	Sometimes	Often	Never	Often	Never	Never	Never	
11	Package	Often	Sometimes	Never	Never	Never	Never	Often	Integration to 3D CAD systems
12	Customised	Often	Sometimes	Never	Often	Never	Never	Sometimes	
13	Customised	Often	Sometimes		Sometimes				
14	Customised	Never	Never	Never	Sometimes	Often	Often		
15	Package		Always		Always	Always			
16	One off	Never	Never	Never	Often	Never	Sometimes		
17	One off	Sometimes	Often	Never	Sometimes	Never	Never	Never	
18	Customised	Often	Often	Sometimes	Often	Never	Never		
19	Package	Often	Sometimes	Never	Often	Never	Never		
20	One off	Never	Never	Never	Never	Never	Never	Always	Web Applications
21	Customised	Often	Never	Often	Sometimes	Never	Never	Never	
22	Customised	Never	Often	Sometimes	Always	Never	Never		
23	One off	Often	Often	Often	Often				
24	One off	Sometimes	Sometimes	Sometimes	Never	Never	Sometimes		
25	One off	Often		Never	Often	Sometimes	Never		
26	Customised	Never	Never	Always	Never	Always	Never	Never	
27	One off	Often	Sometimes	Never	Always	Never	Never		
28	Package	Often	Sometimes	Sometimes	Always	Sometimes	Always		
29	Customised	Often	Sometimes	Never	Always	Never	Sometimes	Never	
30	Customised	Always	Often	Always	Always	Never	Sometimes		

Table 22 Types of Software

PROJECT INFORMATION			
No	**Typical length of Software development projects**	**Typical no of employees involved**	**Requirements Engineering % of total project effort**
1	3-6 months	3-9	31-35
2	7-12 months	<3	31-35
3	3-6 months	3-9	11-15
4	7-12 months	3-9	0-5
5	<3 months	<3	16-20
6	3-6 months	<3	6-10
7	1-3 years	<3	26-30
8	3-6 months	<3	51-55
9	3-6 months	3-9	16-20
10	3-6 months	<3	21-25
11	3-6 months	3-9	11-15
12	<3 months	<3	11-15
13	3-6 months	3-9	
14	3-6 months	3-9	0-5
15	<3 months	3-9	0-5
16	3-6 months	<3	11-15
17	<3 months	<3	6-10
18	3-6 months	3-9	36-40
19	<3 months	<3	26-30
20	3-6 months	3-9	16-20
21	3-6 months	3-9	26-30
22	3-6 months	<3	
23	3-6 months	<3	0-5
24	<3 months	<3	16-20
25	3-6 months	<3	16-20
26	7-12 months	<3	21-25
27	<3 months	<3	21-25
28	3-6 months	3-9	0-5
29	3-6 months	<3	6-10
30	7-12 months	3-9	16-20

Table 23 Project Information

FORMALITY OF PROCESSES AND SPECIFICATION LANGUAGE		
No	**Formality of the requirements engineering process**	**Formality of the language used in requirements specifications**
1	Clear phases with a mixture of formal and informal processes	Semi-formal
2	Clear phases with formal processes	Semi-formal
3	Clear phases with a mixture of formal and informal processes	Semi-formal
4	Clear phases with a mixture of formal and informal processes	Semi-formal
5	No explicit process	No formality
6	Clear phases with informal processes	No formality
7	Clear phases with informal processes	Semi-formal
8	Clear phases with a mixture of formal and informal processes	Semi-formal
9	Clear phases with informal processes	Semi-formal
10	Clear phases with a mixture of formal and informal processes	No formality
11	Clear phases with a mixture of formal and informal processes	Semi-formal
12	Clear phases with informal processes	No formality
13		
14	No explicit process	Semi-formal
15	No explicit process	Semi-formal
16	No explicit process	Semi-formal
17	No explicit process	No formality
18	Clear phases with a mixture of formal and informal processes	No formality
19	Clear phases with informal processes	Semi-formal
20	Clear phases with a mixture of formal and informal processes	Semi-formal
21	Clear phases with informal processes	No formality
22		
23	Clear phases with a mixture of formal and informal processes	No formality
24	Clear phases with informal processes	Semi-formal
25	Clear phases with a mixture of formal and informal processes	Semi-formal
26	Clear phases with a mixture of formal and informal processes	Semi-formal
27	No explicit process	No formality
28	No explicit process	No formality
29	Clear phases with informal processes	No formality
30	Clear phases with formal processes	Semi-formal

Table 24 Formality of Processes and Specification Language

USE AND AWARENESS OF RE TOOLS				
No	**Use of tools to support RE processes**	**If yes, please list**	**Awareness of other tools**	**If yes, please list those you are aware of**
1	No		No	
2	Yes	Visio	No	
3	No		Yes	
4	No		No	
5	No		No	
6	No		Yes	but cannot put a name on them
7	Yes	UML Toolkits	Yes	Trac
8	No		No	
9	Yes	Eclipse	Yes	Rational Suite
10	Yes	Prototyping	No	
11	Yes	Enterprise Architect, Visio	No	
12	Yes	Trac, Visual Paradigm's UML modeling	No	
13				
14	No		Yes	Rational, Together
15	Yes	Word	No	
16	No		Yes	
17	No		No	
18	No		Yes	
19	No		No	
20	Yes	Microsoft Word!	No	
21	No		No	
22				
23	Yes	prototyping method	No	
24	Yes	MS Access Relationship diagram (i.e. data model)	Yes	I'm aware they exists, but don't know there names
25	Yes	Relatively recently using a database/web app to record, track, and prioritise requirements	Yes	Many UML tools
26	No		Yes	requirements capture pacakges such as doors.
27	Yes	self developed check lists	Yes	UML
28	No		No	
29	Yes	Flowchart software	Yes	imaging software
30	Yes	Visio	No	

Table 25 Use and Awareness of RE Tools

GUIDELINE IMPLEMENTATION										
	Please indicate which response best describes your organisation's implementation of requirements engineering practices.									
No	Standard requirement document defined	Requirement document easy to change	Each requirement is uniquely identified	Defined policies for requirements management	Standard templates defined for requirement description	Language used simply, consistently and concisely	Formal requirement inspections organised	Requirement validation checklists defined	Checklists used for requirements analysis	Plans created for conflicts and conflict resolution
1	Sometimes	Sometimes	Sometimes	Sometimes	Sometimes	Sometimes	Sometimes	Sometimes	Sometimes	Sometimes
2	Compulsory	Sometimes	Compulsory	Compulsory	Sometimes	Compulsory	Sometimes	Compulsory	Compulsory	Compulsory
3	Normally	Normally	Normally	Normally	Normally	Normally	Sometimes	Never	Never	Normally
4	Never	Normally	Normally	Never	Never	Compulsory	Never	Normally	Normally	Sometimes
5	Sometimes	Normally	Normally	Never	Never	Normally	Never	Never	Sometimes	Compulsory
6	Never	Normally	Normally	Sometimes	Never	Never	Never	Sometimes	Never	Sometimes
7	Sometimes	Normally	Compulsory	Sometimes	Sometimes	Sometimes	Never	Sometimes	Sometimes	Sometimes
8	Compulsory	Compulsory	Compulsory	Sometimes	Sometimes	Normally	Normally	Sometimes	Normally	Normally
9	Normally	Compulsory	Sometimes	Never	Normally	Normally	Sometimes	Sometimes	Normally	Never
10	Sometimes	Normally	Never	Never	Sometimes	Compulsory	Never	Never	Never	Never
11	Normally	Normally	Normally	Sometimes	Normally	Sometimes	Sometimes	Never	Never	Never
12	Normally	Compulsory	Normally	Never	Sometimes	Normally	Never	Never	Never	Never
13										
14	Never	Normally	Never	Never	Never	Normally	Never	Never	Never	Never
15	Sometimes	Never	Sometimes	Never	Never	Normally	Never	Normally	Normally	Never
16	Normally	Normally	Never	Never	Sometimes	Sometimes	Never	Never	Never	Never
17	Sometimes	Sometimes	Sometimes	Never	Never	Sometimes	Never	Never	Never	Never
18	Normally	Normally	Normally	Normally	Normally	Normally	Normally	Sometimes	Sometimes	Sometimes
19	Normally	Normally	Sometimes	Never	Sometimes	Sometimes	Never	Never	Never	Never
20	Compulsory	Sometimes	Sometimes	Sometimes	Compulsory	Normally	Sometimes	Sometimes	Sometimes	Normally
21	Normally	Normally	Normally	Normally	Sometimes		Never	Sometimes	Sometimes	Normally
22										
23	Never	Normally	Normally	Never	Never	Compulsory	Never	Never	Compulsory	Sometimes
24	Sometimes	Compulsory	Sometimes	Never	Never	Normally	Never	Never	Never	Never
25	Normally	Normally	Sometimes	Sometimes		Normally	Normally	Sometimes	Sometimes	Never
26	Normally	Normally	Sometimes	Never		Normally	Sometimes	Sometimes	Sometimes	Never
27	Sometimes	Normally	Sometimes	Never	Never	Never	Never	Sometimes	Normally	Never
28	Never	Normally	Sometimes	Never	Never	Never	Never	Sometimes	Never	Sometimes
29	Sometimes	Normally	Sometimes	Normally	Never	Sometimes	Sometimes	Sometimes	Sometimes	Normally
30	Compulsory	Sometimes	Sometimes	Normally		Compulsory	Compulsory	Sometimes	Sometimes	Never

Table 26 Guideline Implementation

TOP 3 ISSUES			
	What are the top 3 issues facing your organisation with respect to software development and requirements engineering?		
No	**Issue 1**	**Issue 2**	**Issue 3**
1	Client Comprehension	Client Communication	Client Trust
2	Customers wanting to expand requirements after signing off on them	Customers signing off on requirements having not properly read them	Finding unanticpated issues that cause conflict between requiremetns
3	*Client Education re process*	*Client acceptance of initial costs*	*Balance of quality of definitions versus cost relative to total project complexity*
4	Accuracy of Specification	Ramafications of the Specification Not Thought about	None
5	confidentiality	resources	
6	change control	communication	correctness of requirements as explain by customer
7	Consistent transfer of knowledge	We reduced bloat in our apps by sticking to Scrum principles	Idea sharing
8	Getting people to realise you have to pay for it	Getting people to realise it is neccessary	Getting people to realise it takes longer than they think
9	1	2	3
10	Applying Agile processes		
11	Getting the designs documented before development starts	Have too few people capable of understanding the business process therefore driving design	
12	cost to client and percieved benifit	scope creep	developer support / training in formal development methods
13			
14	Customer's lack of understanding their own requirements	Lack of large scale projects to support cost of formal processes	Lack of participation on customers part to improve process
15	Eliciting requirements	Not broad-enough base of user requirements	
16	lack of agreed process	lack fo agreed methodology	
17	none		
18	none		
19	Timely input from clients	Compressed timeframes	
20	Requirement is boring, and NO ONE reads it	Requirement is more like a client contract on functionality	Agile Extreme programming is the best
21	N/A		
22			
23	Cost. In tradional software development the requiremnts phase is 20-25% of project cost. This doesn't work in my model servicing medium sized businesses. My clients wouldn't handle it so we use prototyping so that the client can see some result at an earlier stage and has the confidence to proceed with the project.	Reprography. As bespoke providers we are like scribes competing with the printing press.	Degrading quality of IT staff. As recently as 15 years ago about 1 out of 100 IT staff could actually write a program. Now it's more like 1 out of 1000.
24	changes to Client company personnel	not receiving relevant information from the Client	changes to requirements after delivery (this is not a problem - it's expected, allowed for and why requirements engineering can't be too formalised with the projects that I have)
25	Convincing customers of its necessity - that we should not just start coding	Lack of detailed customer review of requirements before sign-off - there is review, but not always at adequate depth	Changes to customer team in longer running projects can introduce unexpected changes to requirements and priorities
26	time required to fully develop requirements.	correctly extracting/capturing requirements from customer at start of project	chaging requirements late in the process.
27	Priority Management	Coping with change	
28	adding the right software features in the latest release	completing tasks on time	over-engineering
29	Setting boundaries.	Getting clear specifications from clients.	Project organisation.
30	Scope creep	Budget overruns	Tight deadlineshaha

Table 27 Top 3 Issues

IMPORTANCE OF SPECIFIC ISSUES TO THE ORGANISATION								
	Which of the following requirements engineering issues are important to your organisation?							
No	**Quality of requirements (correctness, clarity, completeness etc)**	**Managing changing requirements**	**Communication with customer about requirements**	**Requirements engineering process improvement**	**Reducing the effort spent on requirements engineering**	**Training in requirements engineering**	**Introduction of requirements management tools**	**Introduction of more formal specification methods**
1	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
2	Definitely yes	Definitely yes	Definitely yes	Yes	Not	Neutral	Not	Yes
3	Definitely yes	Definitely yes	Definitely yes	Not	Yes	Neutral	Not	Neutral
4	Yes	Yes	Definitely yes	Not	Neutral	Neutral	Neutral	Definitely not
5	Yes	Neutral	Definitely yes	Not	Neutral	Not	Definitely not	Not
6	Yes	Definitely yes	Definitely yes	Yes	Neutral	Neutral	Neutral	Neutral
7	Definitely yes	Definitely yes	Definitely yes	Definitely yes	Definitely yes	Neutral	Neutral	Neutral
8	Definitely yes	Yes	Definitely yes	Definitely yes	Definitely yes	Definitely yes	Neutral	Yes
9	Yes	Yes	Definitely yes	Neutral	Neutral	Not	Not	Definitely not
10	Yes	Yes	Yes	Yes	Yes	Yes	Neutral	Not
11	Yes	Yes	Neutral	Definitely yes	Yes	Yes	Yes	Definitely yes
12	Definitely yes	Definitely yes	Definitely yes	Yes	Yes	Yes	Neutral	Neutral
13								
14	Yes	Yes	Neutral	Neutral	Yes	Not	Not	Neutral
15	Yes	Not	Not	Neutral	Neutral	Neutral	Neutral	Not
16	Yes	Yes	Yes	Neutral	Neutral	Not	Not	Definitely not
17	Yes	Neutral	Yes	Yes	Neutral	Neutral	Not	Not
18	Yes	Definitely yes	Definitely yes	Yes	Not	Neutral	Yes	Yes
19	Yes	Yes	Yes	Not	Neutral	Definitely not	Definitely not	Not
20	Definitely yes	Definitely yes	Definitely yes	Definitely yes	Definitely yes	Definitely yes	Definitely yes	Definitely yes
21	Yes	Yes	Yes	Neutral	Neutral	Neutral	Neutral	Neutral
22								
23	Yes	Definitely yes	Definitely yes	Neutral	Neutral	Neutral	Not	Not
24	Yes	Neutral	Definitely yes	Definitely not	Not	Not	Definitely not	Not
25	Yes	Definitely yes	Definitely yes	Neutral	Not	Yes	Neutral	Neutral
26	Definitely yes	Yes	Definitely yes	Neutral	Neutral	Neutral	Not	Definitely not
27	Yes	Definitely yes	Neutral	Neutral	Not	Not	Not	Not
28	Not	Not	Neutral	Neutral	Not	Not	Not	Not
29	Definitely yes	Yes	Definitely yes	Neutral	Neutral	Neutral	Not	Not
30	Definitely yes	Yes	Definitely yes	Neutral	Definitely yes	Neutral	Neutral	Neutral

Table 28 Importance of Specific Issues to the Organisation

Appendix H Interview Responses

1. What are the job title(s) of the person(s) primarily responsible for requirements engineering in your organisation?

   Managing Director, Software Developer, Business Analyst/Project Manager

2. What are their responsibilities?

   Varies, but in this area principally meeting with customers, analysis of customer needs, preparation of overview documents, formal requirements investigation with customers (methods vary), documentation of requirements, preparation of project plans with developers, preparation of test plans with customers.

3. Please provide details of any, formal education and/or training have they had in requirements engineering? (course name, length and provider – industry, PTE or Tertiary institution).

   Typically only requirements engineering as part of tertiary degrees in ICT, or in some cases a Requirements course or software development training course from a provider like Software Education

4. Do you consider there is sufficient literature and training available for requirements engineers?

   There is plenty of material (not always in agreement of course) for those who will invest time to attend training or in reading/study.

5. What additional information and training could be provided to assist?

   There is always room for better academic training. It is hard to find new graduates who have an explicit interest in requirements engineering or business analysis (lots of programmers or IT management!). Recent graduate programmers who have completed a generalised ICT degree with a programming emphasis seem particularly weak in requirements engineering.

6. What value do you place on industry training?

   In this area industry training is useful, although in some parts it can overly focus on the current tools (particularly software) more than principles. However, training I have attended has been useful.

7. What value do you place on academic training?

   This is critical. There were some useful courses when I studied (many years ago), an I know variations of these are still around, but I believe there is value in a stronger emphasis in this area for undergraduates, and possibly short course/diploma study for people already in the industry.

8. If university graduates had stronger education in Requirements Engineering, would this be of benefit to your business and why?

   You've probably guessed from my answers that this is an area I have personal experience in. Yes, we need graduates who have formal education in this area AND have ideally combined this with real world work of some sort - so they see how things play out in reality too.

9. What are the main areas of concern you have about requirements engineering in your organisation

   We lack sufficient focus on it. We are a small business, so the team need to be multi-skilled. For those with technical skills, this means a personal preference towards doing rather than documenting. I have to be firm about what is required to ensure we get sufficient quality and detail in requirements deliverables.

10. Can you expand on your top three issues and the impact they have on your business

    a. Insufficient skilled requirements engineering resource with the necessary interest in or understanding of our main customers' sector

    b. Lack of skill/experience in our customers in the requirements engineering process (I've sketched out our basic problem - do I really have to engage more in coming up with the details of the solution?)

    c. Lack of skill/experience in our customers in the testing and acceptance process (and lack of time or resource allocation).

11. On a scale of 1-10, where 1 is extremely dissatisfied and 10 is extremely satisfied, how satisfied are you with the quality of requirements engineering in your organisation?

    Around 7 - we have made good steps forward but have a way to go.

12. What proportion of your projects meet the requirements as documented?

    Around 95% - but this includes change management whereby requirements are added, removed, or clarified during the process. I'd like to catch some of these earlier, although we also try to use reasonably agile development processes (sprints to deliver early builds) so that we can pull out missing requirements and clarifications as early as possible.

13. What proportion of your projects meet the business requirements for the project?

    Around 95% - eventually. But sometimes this takes some clarification, changes, or rework.

14. What, if any, quality standards that you are required to meet?

    We have a manual that specifies the processes and deliverables to be produced. The internal quality of these deliverables is more subjective (see below).

15. How would you measure the quality of your requirements engineering activities?

    I measure these with the team by reviewing engagement with the customer (subjective), quality and completeness of the requirements documentation and database, number of necessary change requests (given project size) and timeliness of delivery and feedback from the customer. Some of this could be made more objective or have defined metrics.

16. Please describe the methodology do you follow for software development.

    Most of our customers require a fixed price quote, and assume a fixed scope project (we have discussed the agile approach of a fixed price and schedule project with variable scope, but have not yet had a customer bite).

    Once initial engagement is confirmed we undertake a requirements gathering step followed by or accompanied by high-level software design. Requirements gathering comprises one on one meetings with customer staff, as well as larger meetings and presentations, and analysis of documents provided by the customer. Requirements are captured in a database and presentedin a Software Requirement Specification document. Because we expect to work interactively with the customer, the focus is on capturing the heart of business requirements, rather than necessarily every detail.

A design phase follows, during which time the application architecture and data model are considered and where relevant, user interface or layout structure is developed. The project team size the project, and plan how the project will be scheduled around other work and the customer's needs. At the end of that process, a quotation for development is provided.

Our software development approach varies with the team and customer needs, but generally involves a number of fixed duration sprints with deliverable milestones at the conclusion of each which allow testing and feedback from the customer.

A final acceptance testing and handover period takes place, and at this time we sometimes receive new requirements, as the customer decides on other ways they could use the software in their business. Generally we view this as a good thing for customer satisfaction, but it can make scheduling subsequent projects a resource challenge.

17. What issues do you have with it?

Managing multiple projects which may draw on overlapping team members is a challenge. In an ideal world we would manage this more effectively, but changing customer requirements (and in a few cases missed customer requirements) can make projects extend out.

18. Please describe the methodology you follow for requirements engineering.

Once initial engagement is confirmed we undertake a requirements gathering step followed by or accompanied by high-level software design. Requirements gathering comprises one on one meetings with customer staff, as well as larger meetings and presentations, and analysis of documents provided by the customer. Requirements are captured in a database and presentedin a Software Requirement Specification document. Because we expect to work interactively with the customer, the focus is on capturing the heart of business requirements, rather than necessarily every detail.

We use templates as checklists to make sure we have asked the necessary questions, especially for non-functional requirements that may affect the usage of the resulting software.

19. What issues do you have with it?

If the client will engage with this process, it usually works pretty well.

20. Does it cover each of the main activities?

h.	Elicitation	Yes☒ No☐
i.	Analysis and negotiation	Yes☒ No☐
j.	Validation	Yes☒ No☐
k.	Description	Yes☒ No☐
l.	Prioritisation	Yes☒ No☐
m.	Traceability	Yes☐ No☒
n.	Management	Yes☒ No☐

21. What, if any, tools do you use to support the following requirements engineering activities?

h. Elicitation

Whiteboards and paper primarily. At times we will use diagrams and paper prototypes.

i. Analysis and negotiation

First draft of capturing requirements in our Gemini database, and clarification of issues by phone, meeting, or email.

j. Validation

Feed back of requirements to the customer (at various levels, including the potential users and the key customer contacts). We tend to just use Word, Powerpoint, and the whiteboard.

k. Description

Gemini, plus diagrams generated in Visio etc, which are often attached.

l. Prioritisation

Requirements are prioritised interactively with the customer (we will often suggest a first rating based on our discussions with the customer

m. Traceability

I checked the NO box by traceability, but in fact we are getting better at this. We use a software tool and database called Gemini, and are beginning to track linked and replacement requirements, and are starting to track tests off those

requirements. We are now working on the team incorporating requirement references into the relevant units of their code. At an elucidation level, we need to track where we got a requirement from better than we currently do.

n. Management

The one area Gemini is a large help is that it is a database or master list that can be managed, prioritised, approved, etc.

22. Do you have any further comments about Requirements Engineering in your organisation or in the software development industry?

No.

Thank you for your participation

If you are interested in receiving a Requirements Engineering Capability Assessment for your company would you please complete the attached additional questionnaire.

The outcome of a capability measurement is that a company is graded on a scale that represents the maturity of its processes, or in other words, how well advanced the organisation is in terms of consistency and completeness, and seeking to continually improve its performance in delivering quality software. It will also highlight possible areas for improvement.

Capability Assessment Questionnaire

For each of the Requirements Engineering activities below please select the response that best describes your organisation's implementation of that activity. In order for an assessment to be made all questions should be answered. Use the "Not Applicable" option if you consider the activity is not relevant to your organisation. When you have finished please save the document and return via email.

Organisation: Click here to enter text.

Guideline	Applicability	Implementation
Basic Guidelines		
Define a standard document structure	Requirements Document	*Compulsory*
Explain how to use this document	Requirements Document	*Normally*
Include a summary of the requirements	Requirements Document	*Normally*
Make a business case for the system	Requirements Document	*Normally*
Define specialised terms	Requirements Document	*Normally*
Lay out the document for readability	Requirements Document	*Compulsory*
Help readers find information	Requirements Document	*Normally*
Make the document easy to change	Requirements Document	*Normally*
Assess system feasibility	Requirement Elicitation	*Normally*
Be sensitive to organisational and political considerations	Requirement Elicitation	*Sometimes*
Identify and consult system stakeholders	Requirement Elicitation	*Normally*
Record requirements sources	Requirement Elicitation	*Sometimes*
Define the system's operating environment	Requirement Elicitation	*Compulsory*
Use business concerns to drive requirements elicitation	Requirement Elicitation	*Normally*
Define system boundaries	Analysis and Negotiation	*Normally*
Use checklists for requirements analysis	Analysis and Negotiation	*Sometimes*
Provide software to support negotiations	Analysis and Negotiation	*Sometimes*
Plan for conflicts and conflict resolution	Analysis and Negotiation	*Sometimes*
Prioritise requirements	Analysis and Negotiation	*Compulsory*
Define standard templates for describing requirements	Describing Requirements	*Normally*
Use language simply and concisely	Describing Requirements	*Normally*
Use diagrams appropriately	Describing Requirements	*Sometimes*
Supplement natural language with other descriptions of requirements	Describing Requirements	*Sometimes*
Develop complementary system modelling	System Modelling	*Sometimes*
Model the system's environment	System Modelling	*Never*
Model the system architecture	System Modelling	*Normally*
Check that the requirements document	Requirement Validation	*Compulsory*

meets your standards		
Organise formal requirements inspections	Requirement Validation	*Sometimes*
Use multi-disciplinary teams to review requirements	Requirement Validation	*Normally*
Define validation checklists	Requirement Validation	*Sometimes*
Uniquely identify each requirement	Requirement Management	*Normally*
Define policies for requirements management	Requirement Management	*Compulsory*
Define traceability policies	Requirement Management	*Sometimes*
Maintain a traceability manual	Requirement Management	*Never*
Create safety requirements checklists	Critical systems	*Sometimes*
Involve external reviewers in the validation process	Critical systems	*Sometimes*
Intermediate Guidelines		Choose an item.
Look for domain constraints	Requirement Elicitation	*Sometimes*
Record requirements rationale	Requirement Elicitation	*Normally*
Collect requirements from multiple viewpoints	Requirement Elicitation	*Sometimes*
Prototype poorly understood requirements	Requirement Elicitation	*Sometimes*
Use Scenarios to elicit requirements	Requirement Elicitation	*Normally*
Define operational processes	Requirement Elicitation	*Normally*
Classify requirements using a multi-dimensional approach	Analysis and Negotiation	*Never*
Use interaction matrices to find conflicts and overlaps	Analysis and Negotiation	*Never*
Specify requirements quantitatively	Describing Requirements	*Normally*
Use structured methods for system modelling	System Modelling	*Sometimes*
Use a data dictionary	System Modelling	*Normally*
Document the links between stakeholder requirements and system models	System Modelling	*Sometimes*
Use prototyping to animate requirements	Requirement Validation	*Sometimes*
Write a draft user manual	Requirement Validation	*Sometimes*
Propose requirements test cases	Requirement Validation	*Sometimes*
Use a database to manage requirements	Requirement Management	*Compulsory*
Define change management policies	Requirement Management	*Compulsory*
Identify global system requirements	Requirement Management	*Normally*
Identify and analyse hazards	Critical systems	*Sometimes*
Derive safety requirements from hazard analysis	Critical systems	*Never*
Cross-check operational and functional requirements against safety requirements	Critical systems	*Sometimes*
Advanced Guidelines		Choose an item.
Reuse requirements	Requirement Elicitation	*Sometimes*
Assess requirements risks	Analysis and Negotiation	*Normally*

Paraphrase system models	Requirement Validation	*Sometimes*
Identify volatile requirements	Requirement Management	*Normally*
Record rejected requirements	Requirement Management	*Sometimes*
Specify systems using formal specification	Critical systems	*Never*
Collect incident experience	Critical systems	*Sometimes*
Learn from incident experience	Critical systems	*Sometimes*
Establish an organisational safety culture	Critical systems	*Never*