Nelson Mandela Metropolitan University
for tomorrow

THE MATURITY OF PROJECT MANAGEMENT IN ENGINEERING CONSULTING FIRMS

A TREATISE SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE (BUILT ENVIRONMENT) PROJECT MANAGEMENT

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STATEMENT

The data used in the compilation of this treatise was taken from both primary and secondary sources. The secondary sources used in this treatise, as well as the help acquired, have been duly acknowledged.

I certify that this treatise is my own work and that it has not been plagiarised or submitted to another university before.

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Kennedy Machite **Date**

DEDICATION

This treatise is dedicated to my lovely wife for her unending encouragement.

ACKNOWLEDGEMENTS

I would like to express my gratiude to the following people :

- Dr B. Botha for his invaluable time, insight and guidance in supervising the research,
- My family for affording me time to complete the research

ABSTRACT

With a considerable number of built environment projects not being completed successfully, this study was undertaken to investigate how effectively consulting engineering firms are applying project management principles in the way they manage projects. This was achieved by measuring the project management maturity levels of consulting engineering firms. Maturity levels were measured for each of the ten knowledge areas of the Project Management Institute's Project Management Body of Knowledge to determine areas where consulting engineering firms perform below expectation and as a result determine probable causes of project failures. The maturity of the firm was then calculated as the average of the maturity for the knowledge areas.

The study found that consulting engineering firms have higher levels of project management maturity than the average for the construction and civil engineering sector. Apart from risk and procurement management, all the other knowledge areas have higher maturity levels than the corresponding construction and civil engineering knowledge areas.

Although the overall maturity results indicate that the larger firms are more mature in their project management practices than the smaller firms, the individual knowledge areas are inconsistent. The study reveals that consulting engineering firms are weakest in the risk management, human resources and stakeholder management knowledge areas.

There is limited literature available on the status of project management, project management methodologies, and performance of consulting projects in the engineering environment (Labuschagne & Steyn, 2010:70). There is need for future studies to establish a methodology developed specifically for the Consulting Engineering Firms in line with what Labuschagne & Steyn (2010) started and a Project Management Maturity Model specific to the Consulting Engineering Industry.

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1 CHAPTER ONE: THE PROBLEM AND ITS SETTING

1.1 Introduction

A significant number of projects undertaken by a civil engineering consulting firm that the researcher worked for (called firm X for the purpose of this research) performed below the desired levels, by having more than 50% of their projects delivered behind schedule, over budget or with poor quality. Also, a review of literature to investigate the level of success or failure of engineering projects indicates that several studies have been carried on the subject of project failures. Many of these studies concluded that most projects fail because project management principles are not always being applied sufficiently. This prompted the researcher to investigate how effectively consulting engineering firms are applying project management principles in the way they manage projects. This was achieved by measuring the project management maturity levels of consulting engineering firms. Maturity levels were measured for each of the ten knowledge areas of the Project Management Institute's Project Management Body of Knowledge to determine areas where consulting engineering firms perform below expectation and as a result determine probable causes of project failures. Recommendations were then made on where to improve project management maturity levels in order to improve the success rates of delivery of engineering projects. The research results are a source of benchmark data for the current level of project management maturity of consulting engineering firms, overall and in each project management knowledge area.

1.2 Background to problem statement

Review of the project database for firm X's Port Elizabeth office revealed that more than 50% of the projects they had undertaken during the previous two years had not been completed successfully; they were either completed late, completed above budget or had quality issues. Those that were ongoing at the time this research commenced, were besieged with problems that also included cost and time overruns and poor quality.

A scan of the relevant literature on the causes of project failures indicates that a lot of studies have been conducted to investigate why civil engineering projects fail. For instance, Samuel (2007:3) noted that cost management is not applied effectively since on average only 60% of projects are completed within budget against the desired level of 95%. The author attributed the main reason for this to poor scope definition by the client as well as poor project conceptualisation and design, which situation results in an extremely high percentage of variation orders which places tremendous strain on project budgets. Samuel (2007:11) concluded that project failure is due to numerous factors which include failure resulting from a low contract price, ignorance of usage of proper time planning processes, failure as a result of poor project quality management, and poor project scope definition by the Government (client), and lastly due to the poor translation of the scope into design and documentation by the professional team. Aiyetan (2010) cited consultants as contributors to delays and further cites factors contributed by consultants to include late instructions, poor dimensional coordination, late approval of work, late preparation of interim valuations and certificates by the contractor, as well as late inspection and approval of work. Project failures with respect to time and cost are attributed to a misalignment of project objectives between consultants and client, miscommunication between design and construction departments/contractors, absence of project management practices, and dissatisfaction on the part of the sponsors (Labuschagne and Steyn, 2010:70)

The foregoing studies indicated that reasons for project failures cut across processes contained in most of the ten Project Management Body of Knowledge (PMBOK®) knowledge areas, which is an indication that project management best practices are not always being effectively utilised by some consulting engineering firms (CEFs).

Research has revealed that there is a relationship between project performance and the level of project management maturity (PMM) within an organisation. For example, PricewaterhouseCoopers (PWC) (2004:9) concluded that there is a correlation between project performance and PMM in that organisations with more mature project management practices deliver superior performance in

terms of overall project delivery. This indicates that determining the level of PMM of an organisation will give an indication of how successful project management best practices are being implemented in the consulting engineering firms.

1.3 The Statement of the problem

The failure in the successful completion of some engineering projects reveals shortcomings which may be ascribed to low levels of project management maturity of the built environment professionals. This study will investigate the project management maturity of consulting engineering firms.

1.3.1 The sub-problems

Sub-problem 1: The level of project management maturity in consulting engineering firms is contributing to failure of infrastructure projects

Sub-problem 2: The smaller firms have higher incidences of project failures than the bigger firms

1.3.2 The hypotheses

Hypothesis 1: The level of project management maturity is low for consulting engineering firms when compared to the average in the engineering and construction industries in South Africa.

Hypothesis 2: Smaller firms have lower levels of project management maturity than the bigger firms.

1.4 Demarcation of the study

1.4.1 Geographical demarcation

The empirical component of the research, which was conducted by internet questionnaires, was conducted at consulting engineering firms in South Africa.

1.4.2 Discipline demarcation

The research was limited to consulting engineering firms.

1.4.3 Role demarcation

Although there are many factors and other role-players that also affect the outcome of projects, the research was limited to the practice of project management processes and the role of consulting engineering firms in delivering projects.

1.4.4 Firm sizes

For the purpose of this research, firms were categorised as micro, small, medium and large in size. Industry Insight (2013: 10) categorises firms with less than 20 people as small, those with between 20 and 100 people as medium and those with above 100 people as large. The following demarcation was adopted for this research:

- Micro: 1-5 employees
- Small: 5-20 employees
- Medium: 20-100 employees
- Large: >100 employees

1.4.5 Target group

The questionnaires were distributed among senior personnel who are tasked with leading projects in their firms. Depending on the firm's structure, these were project managers, project engineers, project leaders or associates.

1.5 Definition of terms

Client – Any juristic person or organ of the state engaging a consulting engineer for services on a project. (Government Gazette, 2010:4)

Consulting engineer – any professional registered in terms of the Engineering Professions Act, 2000 (Act No. 46 of 20000), or a juristic person who employs such professional, engaged by a client on a project (Government Gazette, 2010:4)

Firm – is defined by CESA (Norton Rose, 2013:4**)** as:

… a natural person or legal entity which provides primarily independent technology-based intellectual services in the built, human and natural environment to clients for a fee, and which may be any of the following:

- *(a) a Registered Principal who is a sole practitioner…*
- *(b) a partnership in which Registered Principals constitute at least 50 per cent of the partners; or*
- *(c) a close corporation in which Registered Principals constitute at least 50 percent of the close corporation members; or*
- *(d) a company in which Registered Principals constitute at least 50 percent of the directors of the company appointed in terms of the Act;*
- *(e) a subsidiary or regional office or associate office in South Africa of a foreign firm, that:*
    - *(i) is appropriately registered in South Africa,*
    - *(ii) is under full time control of a Registered Principal, and*

(iii) in which locally based Registered Principals constitute at least 50 percent of the principals of the locally registered entity;

Engineering Project – means the project of which the scope comprises mainly engineering work (Government Gazette, 2010:5)

Project means any total scheme envisaged by a client, including all the works and services concerned (Government Gazette, 2010:5), or a temporary endeavour undertaken to create a unique product, service or result (PMBOK® Guide, 2013:3)

Project management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements (PMBOK® Guide, 2013:5)

Project management maturity is the progressive development of an enterprise-wide project management approach, methodology, strategy and decision-making process **(**Tarne, 2007). The appropriate level of maturity will vary for each organisation based on specific goals, strategies, resource capabilities, scope and needs. The five project management maturity levels are defined as follows:

Level 1 — Initial Process: *Processes are ad hoc. Management is aware of project management, but hasn't yet taken steps to formalise it.*

Level 2 — Structured Process and Standards: *basic processes are defined, but not used on all projects. Management supports the use of project management processes.*

Level 3 — Organisational Standards and Institutionalised Process: *the processes are repeatable and standard for projects.*

Level 4 — Managed Process: *project management processes have become integrated with corporate processes. Management mandates the use of the project management processes.*

Level 5 — Optimising Process: *the focus now is on continuous improvement of the processes.*

Maturity model - A maturity model aids in defining, understanding, and measuring an organisation's processes and its effectiveness (ter Haar, 2008:8)

The PMBOK® Guide is a set of ethics and standards developed by the Project Management Institute (PMI) for the project management profession. The PMBOK® is an inclusive term that describes the sum of knowledge within the profession of project management (Sonnekus and Labuschagne, 2003:5). There are ten knowledge areas that are divided into two main categories, namely core functions (scope, time, cost and quality) and facilitating functions (human resource, communication, risk, procurement and stakeholder) with integration management tying it all together. The knowledge areas are subdivided into processes. There are 47 processes and these are mapped onto the five process groups which are initiating, planning, executing, controlling and closing.

1.6 The abbreviations

CESA - Consulting Engineering South Africa
CE - Consulting Engineer
CEF - Consulting Engineering Firm
ECSA - Engineering Council of South Africa
GSS – Guideline Scope of Services
KA - Knowledge area
PM - Project management
PMI - Project Management Institute
PMO - Project Management Office
PMM - Project management maturity
PMMM - Project management maturity model
PMBOK® Guide **-** The Project Management Body of Knowledge Guide
SACPCMP - South African Council for the Project and Construction Management Professions

1.7 The assumptions

The fundamental assumption in this study is that an organisation's project management maturity (PMM) level has a direct correlation with its effectiveness in delivering successful projects, that is, a higher maturity level for a firm enhances overall project performance, and a lower PMM level indicates poor or non-existent project management practices. All project management maturity models (PMMMs) are predicated on the assumption that increases in project management maturity will lead to more consistent and more successful project outcomes (Mullaly, 2014:171). According to Mullaly (2014:171), maturity models, by their nature, have a number of inherent presumptions embedded into their structure and application. Foremost among these assumptions is the belief that a better process delivers improved results. Maier et al. (2012) as quoted by Mullaly (2014:171) also point out that related to this assumption is the linearity and progression inherent in subsequent stages of maturity.

1.8 The importance of the study

Consulting engineering firms will benefit from the research in various ways. Firstly the project management maturity levels of firms in South Africa will be documented once this research is completed. The results of the research will indicate the project management knowledge areas and processes that firms are weak at and this will indicate the probable contributory causes of failure of engineering projects. The industry will benefit in that the research will be a source of benchmark data for the current level of project management maturity of consulting engineering firms, overall, and in each of the ten project management knowledge areas. The results will also indicate the difference in project management maturity between the various firm sizes ranging between micro firms (1-5 employees) and large firms (>100 employees).

1.9 Research objectives

1.9.1 Primary research objective

To measure the project management maturity levels of consulting engineering firms, overall, and for each project management knowledge area.

1.9.2 Secondary research objectives

i) To identify the correlation between the PMM levels and the size of the CEFs.

ii) To make recommendations on which knowledge areas need improvement in order to improve the success rates of engineering projects.

iii) To use the research findings as a source of benchmark data for the current level of project management maturity of CEFs, overall and in each project management knowledge areas.

This chapter outlined the background to the research problem and has given an overview of the study which will be used as a framework for the research. The next chapter examines the relevant literature.

2 CHAPTER TWO: REVIEW OF THE RELATED LITERATURE

2.1 Introduction

The aim of this section is to examine the relevant literature regarding the background of the consulting engineering industry and to investigate the prevalence of project management practices in the industry. The methodologies used in the industry will then be explored in order to determine the most applicable model to use to measure the maturity of project management in the industry. The origin, types and assessment of the most common project management maturity models (PMMMs) will then be examined. The relationship between maturity and project outcome is explored, so is the relationship between the size of an organisation and the project outcome.

2.2 Industry background

2.2.1 Consulting engineering as a professional business service industry

A consulting engineering firm's primary mission is project delivery for a fee. Successful project delivery is critical to the success of organisations that manage by project or rely extensively upon projects to achieve corporate goals (Pennypacker & Grant, 2003:1). Timely completion of projects within budget and on specifications is of strategic importance to the consulting engineers to ensure good market share in the engineering industry (Labuschagne and Steyn, 2010:70).

Consulting engineering companies operate as service providers for customers, predominantly owners of the coming building or infrastructure. Sometimes the cooperation with clients is direct, and at other times indirect through partners or consortia. Consulting engineering is, therefore, a part of a broader business service sector which can be regarded as knowledge intensive (Koch, 2004:279). The consulting engineering companies' core competencies

comprise multidisciplinary engineering, project management, construction management, structural engineering, electrical, mechanical, environmental and energy engineering (STD, 2002) as quoted by Koch (204:279). Engineering consulting work for a construction project generally includes planning, design, and construction supervision. According to Chang and Chiu (2005:179), engineering design has a high level of influence on construction.

2.2.2 Consulting Engineers South Africa (CESA)

The South African consulting engineering sector is diverse, comprising a variety of sub-disciplines, such as civil engineering, mechanical engineering, structural engineering, highways and transportation engineering, mining services and electrical engineering. Consulting Engineers South Africa (CESA) is a voluntary association of independent consulting engineers in private practice. As of 2009 its membership included 460 firms employing more than 20,000 people (Condon, Stern and Truen, 2009:5).

Over half the firms registered with the CESA employ less than 10 employees. The majority of the firms are privately owned. Industry consolidation has become a noticeable trend in recent years and larger firms have come to play an increasingly dominant role. In 2004, large firms employed 60% of the total professionals in the industry; by 2008, large firms (23% of the total number of firms) employed 81% of industry staff (Condon, Stern and Truen, 2009:5)

Members of the Consulting Engineers South Africa, in conducting their practices as consulting engineers and allied professionals, are expected to abide by the CESA Code of Conduct (CESA 2011).

CESA is recognised by the Engineering Council of South Africa as a Voluntary Association in terms of sections 25(3) & 36(1) of the Engineering Profession Act, 2000 (Act 46 of 2000).

2.2.3 Engineering Council of South Africa (ECSA)

The Engineering Council of South Africa (ECSA) was formed under the Engineering Professions Act, 2000 (Act No. 46 of 2000), in order:

> *"To provide for the establishment of a juristic person to be known as the Engineering Council of South Africa; to provide for the registration of professionals, candidates and specified categories in the engineering profession; to provide for the regulation of the relationship between the Engineering Council of South Africa and the Council for the Built Environment; and to provide for matters connected therewith" (*Republic of South Africa, 2000:3)

Among the matters that ECSA deals with, under Section 34(2) of the Engineering Professions Act, is the determination of the guideline scope of services (GSS) and tariff of fees in the schedule.

2.2.4 South African Council for the Project and Construction Management Professions (SACPCMP)

The South African Council for the Project and Construction Management Professions (SACPCMP) is a statutory body established by section 2 of Act No. 48 of 2000 to regulate the Construction and Project Management Professions, in order:

> *"To provide the establishment of a juristic person to be known as the South African Council for the Construction and Project Management Professions: to provide for the registration of professionals, candidates and specified categories in the project and construction management professions: to provide for the regulation of the relationship between the South African Council for the South African Council for the Project and Construction Management Professions and the Council for the Built Environment; and to provide for matters connected therewith" (*Government Gazette, 2000:1)

2.2.5 The role of engineer in projects

Typical services that are carried out by CEF's, according to Board Notice 190 of 2010 (Government Gazette, 2010: 7-21), are summarised in **Table 2-1** below**.**

Table 2-1: Typical scope of services in the consulting engineering industry (Adapted from Government Gazette, 2010: 7-11)

GSS Item	Description	Typical Deliverables
3.1	**Planning, Studies, Investigations and Assessments**	• Collation of information • Technical and financial feasibility • List of consents and approvals • Schedule of required surveys, tests and investigations
3.2	**Normal Services**	
3.2.1	**Stage 1**: Inception	• List of consents and approvals • Schedule of required surveys, tests and investigations
3.2.2	**Stage 2**: Concept and Viability	• Concept design • Preliminary design • Cost estimates
3.2.3	**Stage 3**: Design Development	• Design development drawings • Outline specifications • Local authority submission drawings and reports • Detailed estimates of construction costs
3.2.4	**Stage 4**: Documentation and Procurement	• Specifications, services coordination, working drawings • Budget construction cost • Tender documentation • Tender evaluation report and recommendation
3.2.5	**Stage 5**: Contract Administration and Inspection	• Schedule of predicted cash flow, construction documentation, estimates for variations, financial control reports, valuation of payment certificates etc. • Establish and maintain a financial control system.
3.2.6	**Stage 6**: Close-out	• Payment certificates, • Works and final completion lists, • As-built drawings, final accounts
3.3	**Additional Services**	
3.3.1	Additional Services pertaining to all Stages of the Project	• Incorporation of any targeted participation goals • Measuring of key participation indicators
3.3.2	Construction Monitoring	• Schedule of predicted cash flow, construction documentation, estimates for variations, financial control reports, valuation of payment certificates etc. • Establish and maintain a financial control system.

GSS Item	Description	Typical Deliverables
3.3.3	Occupational Health and Safety Act, 19 (Act No. 85 of 1993)	• To act as the Client's Health & Safety agent
3.3.4	Quality Assurance System	• To set up a quality assurance system additional to the normal service
3.3.5	Lead Consulting Engineer	• Overall administration of all sections of the services, including services falling within the ambit of other CE's. • Overall coordination, programming of design and financial management • Processing contractor's certificates
3.3.6	Engineering Management Services	• Project Brief • Agreed scope of works and Agreed Services • Project Procurement Policy • Signed Agreements, Integrated schedule of consents and agreements • Project initiation, documentation and construction programmes • Record of all meetings • Completion certificates • Close-out reports
3.3.7	Mediation, Arbitration and Litigation proceedings and similar services	• Dealing with matters of law, assisting with mediation and arbitration proceedings, attending courts etc
3.3.8	Principal Agent of the Client	• Detailed design and documentation programme.

A typical project cycle applicable to most engineering projects involves stages 1 to 6 under normal services. During stage 1 to stage 4 the consultant is predominantly responsible for the project deliverables. The contractor's involvement starts at stage 4, when it is invited to tender for a project. The contractor becomes predominantly responsible for construction at stage 5, while the engineer's role is limited to monitoring the construction process. The engineer is responsible for the project close-out (stage 6) with the contractor providing input in the form of "as-built" drawings and test results as required by the contract.

Different role players have different levels of dominance in a typical consulting engineering project life cycle. The client is involved throughout, with the level of involvement highest at the initial stage, stage 1. The contractor's role is

dominant at tender and construction stages. The engineer is involved throughout the project life cycle, with varying degrees of dominance. This is illustrated in **Figure 2-1.**

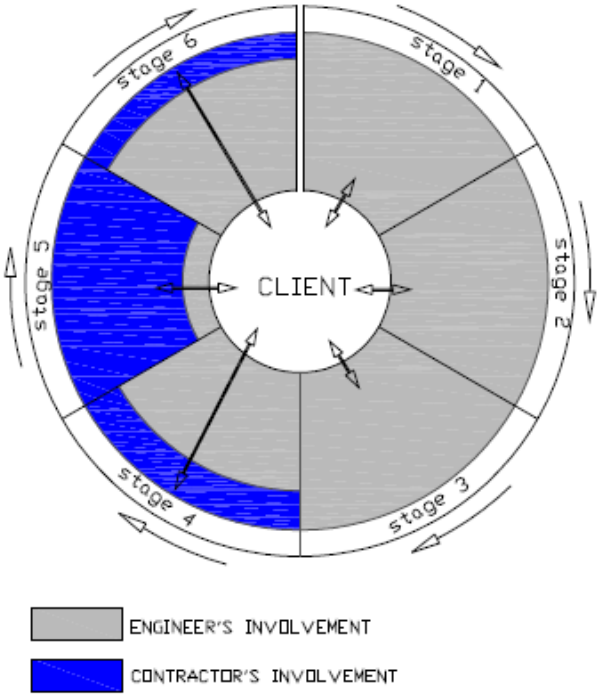

Figure 2-1: The typical roles of Client, Engineer and Contractor in a project.

2.2.6 Conclusion

It can be seen that in a typical engineering project life cycle, the engineer is involved at all stages of the project. During stages 1 to 4, and partly stage 5, the project outcome is dependent to a great extent on the engineer as the dominant role-player. During the construction stage, although the contractor plays a major role, the engineer is actively involved in the monitoring of the construction process, checking the quality of the work, progress, programme and expenditure amongst others.

The engineer's performance therefore has both direct and indirect effect on overall performance of projects. Although the dominance level of the engineer's involvement in a typical engineering project changes as the project progresses in its life cycle, with the contractor taking a dominant role at construction stage,

the engineer has a major role to play in determining the outcome of a project throughout the project life cycle.

2.3 The case for project management

Consulting engineers manage projects by using the guideline for scope of services for engineers regulated by ECSA in the case of normal engineering services. Where the scope of appointment is purely project management, the SACPCMP guideline scope of services is utilised.

2.3.1 Industry guidelines

2.3.1.1 ECSA guideline

Typical services that are carried out by CEF's, according to Board Notice 190 of 2010 (Government Gazette. 2010: 7-21), shown previously in **Table 2-1**, are summarised again in **Table 2-2**, with a column added showing the PMBOK® Guide Knowledge Areas that mostly apply to achieve the deliverables.

Table 2-2.2: Stage deliverables and skills required to produce the deliverables for engineers

GSS Item	Description	Typical Deliverables	Knowledge Area (PMBOK® Guide)
3.1	**Planning, Studies, Investigations and Assessments**	• Collation of information • Technical and financial feasibility • List of consents and approvals • Schedule of required surveys, tests and investigations	Project Integration Management Project Scope Management Project Risk Management
3.2	**Normal Services**		
3.2.1	**Stage 1**: Inception	• List of consents and approvals • Schedule of required surveys, tests and investigations	Project Scope Management
3.2.2	**Stage 2**: Concept and Viability	• Concept design • Preliminary design • Cost estimates	Project Scope Management Project Cost Management Project Risk Management
3.2.3	**Stage 3**: Design Development	• Design development drawings • Outline specifications • Local authority submission drawings and reports	Project Quality Management, Project Cost Management Project Stakeholder

GSS Item	Description	Typical Deliverables	Knowledge Area (PMBOK® Guide)
		• Detailed estimates of construction costs	Management
3.2.4	**Stage 4**: Documentation and Procurement	• Specifications, services coordination, working drawings • Budget construction cost • Tender documentation • Tender evaluation report and recommendation	Project Quality Management , Project Procurement Management Project Cost Management Project Risk Management
3.2.5	**Stage 5**: Contract Administration and Inspection	• Schedule of predicted cash flow, construction documentation, estimates for variations, financial control reports, valuation of payment certificates etc. • Establish and maintain a financial control system.	Scope, Time, Cost, Quality, Communication, Risk and Integration Management
3.2.6	**Stage 6**: Close-out	• Payment certificates, • Works and final completion lists, • As-built drawings, final accounts	Project Quality Management Project Cost Management
3.3	**Additional Services**		
3.3.1	Additional Services pertaining to all Stages of the Project	• Incorporation of any targeted participation goals • Measuring of key participation indicators	Project Procurement Management
3.3.2	Construction Monitoring	• Schedule of predicted cash flow, construction documentation, estimates for variations, financial control reports, valuation of payment certificates etc. • Establish and maintain a financial control system.	Project Scope, Time, Cost, Quality, Communication, Risk and Integration Management
3.3.3	Occupational Health and Safety Act, 19 (Act No. 85 of 1993)	• To act as the Client's Health & Safety agent	Project Risk Management
3.3.4	Quality Assurance System	• To set up a quality assurance system additional to the normal service	Project Quality Management
3.3.5	Lead Consulting Engineer	• Overall administration of all sections of the services, including services falling within the ambit of other CE's. • Overall coordination, programming of design and financial management • Processing contractor's	Project Scope, Time, Cost, Quality, Communication, Risk and Integration Management

GSS Item	Description	Typical Deliverables	Knowledge Area (PMBOK® Guide)
		certificates	
3.3.6	Engineering Management Services	• Project Brief • Agreed scope of works and Agreed Services • Project Procurement Policy • Signed Agreements, Integrated schedule of consents and agreements • Project initiation, documentation and construction programmes • Record of all meetings • Completion certificates • Close-out reports	All Knowledge Areas
3.3.7	Mediation, Arbitration and Litigation proceedings and similar services	• Dealing with matters of law, assisting with mediation and arbitration proceedings, attending courts etcetera.	Procurement, Risk Management
3.3.8	Principal Agent of the Client	• Detailed design and documentation programme.	All Knowledge Areas

It can be seen from **Table 2-2** that most of the skills required to execute the work to produce the expected deliverables can be achieved by applying project management skills that are contained in one of the ten PMBoK® Guide knowledge areas.

2.3.1.2 South African Council for the Project and Construction Management Professions (SACPCMP) Guideline

SACPCMP Guideline standard services that are performed by Construction Project Managers are listed in **Table 2-3**. As in **Table 2-2**, a column has been added showing the PMBOK® knowledge areas that mostly apply to achieve the deliverables.

Table 2-3: Stage deliverables and skills required to produce the deliverables for project managers (Extracted from: Government Gazette, 2011)

Guideline Item	Description	Project Management Deliverables	Knowledge Area (PMBOK® Guide)
3.0	**Standard Services**		
1.0	**Stage 1**: Inception	• Project brief • Project Procurement Policy • Signed Consultant / Client Agreements • Project Initiation Programme • Record of all meetings • Approval by Client to proceed to Stage 2	Project Integration, Scope, Communication and Risk Management
2.0	**Stage 2**: Concept and Viability	• Signed Consultant/Client Agreements • Indicative Project Documentation and Construction Programme • Approval by Client to proceed to Stage 3	Project Scope and Time Management
3.0	**Stage 3**: Design Development	• Signed Consultant/Client Agreements • Detailed Design and Documentation Programme • Updated Indicative Construction Programme • Record of all meetings • Approval by Client to proceed to Stage 4	Project Integration, Scope, Time and Quality Management
4.0	**Stage 4**: Documentation and procurement	• Contractors, subcontractors and Suppliers Procurement Strategy • Project Procurement Programme • Project Tender / Contract Conditions • Record of all meetings • Approval by Client to proceed to Stage 5	Project Procurement, Scope and Quality Management
5.0	**Stage 5**: Construction	• Signed Contractor Agreements • Agreed contract programme • Adjudication and award of	Project Scope, Time, Cost, Quality, Communication, Risk,

Guideline Item	Description	Project Management Deliverables	Knowledge Area (PMBOK® Guide)
		contractual claims • Construction documentation schedule • Monthly progress payment certificates • Monthly project progress reports • Record of all meetings • Certificates of Practical Completion	Procurement, Stakeholder and Integration Management
6.0	**Stage 6**: Close-out	• Works Completion Certificates • Certificate of Final Completion • Record of all meetings • Project closure report	Project Quality Management Project Integration Management

Again, it can be seen that the good practice required to execute the work to produce the expected deliverables can be achieved by applying project management skills that are aligned to one or more of the ten PMBOK® Guide Knowledge Areas.

2.3.2 Previous studies on project outcomes

A number of studies have been carried out to determine the factors that lead to specific project outcomes, especially project failures.

In a research project to investigate the impacts of the four major components (project scope management, project time management, project cost management and project quality management), Doloi and Lim (2007:13) identified 12 critical factors that could affect construction project performance. These critical factors were listed as:

a) *Detailed planning in project budget and cost control*
b) *Project time planning and & schedule control*
c) *Individual or personnel*
d) *Establishment of project quality control*
e) *Ability to perform the required tasks*
f) *Availability of comprehensive project information and specifications*

g) *Competency of key personnel*
h) *Close relationship between project time and cost management,*
i) *Project complexity*
j) *Individual's experience in the construction industry*
k) *Allowance for project contingency*
l) *Detailed WBS and project milestones are clear and well defined.*

In researching project management on Government Projects, Samuel (2007:3) noted that cost management is not applied effectively since an average of only 60% of projects are completed within budget against the desired level of 95%. The author attributed the main reason for this to poor scope definition by the client as well as poor project conceptualisation and design, which situation results in an extremely high percentage of variation orders which places tremendous strain on project budgets. The author concluded that project failure is due to various factors which include failure resulting from a low contract price, ignorance of usage of proper time planning processes, failure as a result of poor project quality management, and poor project scope definition by the Government (client), and secondly to the poor translation of the scope into design and documentation by the professional team.

Aiyetan (2010) cited consultants as contributors to delays and further cited that factors contributed by consultants include late instructions, poor dimensional coordination, and late preparation of interim valuations and certificates by the contractor, as well as late inspection and approval of work.

Project failures with respect to time and cost are attributed to a misalignment of project objectives between consultants and client, miscommunication between design and construction departments/contractors, absence of project management practices, and dissatisfaction on the part of the sponsors (Labuschagne and Steyn, 2010:70)

The reasons for project failures cited from the studies discussed above have been listed in **Table 2-4**. The second column of the table lists the good practice

required to be used to avoid such failures. The third column shows the skill (knowledge area) that mostly applies to handle the challenge.

Table 2-4: Common reasons for project failure, and the skills required to mitigate the failures

Reason for failure (at construction stage)	**Good Practice required from the engineer to avoid similar failure**	**Knowledge Area of Skill required to mitigate the failure[1]**
Cost management not applied effectively, fewer projects completed within budget desired.	• Ensure good scope definition and project conceptualisation at planning stage • Prepare accurate cost estimates at planning. • Closer monitoring and proper change control during construction	Scope management Cost management Integration Management
Low contract price	• Prepare accurate cost estimates at planning. • Do an effective risk analysis at tender evaluation	Cost management Risk management
Poor project quality management	• Ensure the Engineer's Quality Management system is in place for Construction Monitoring.	Quality Management
Translation of the scope into design and documentation by the professional team	• Ensure good scope definition and project conceptualisation at planning stage. • Follow Quality Management System if in place. • Perform integrated change control.	Scope management Quality Management Integration Management
Late instructions by consultants	• Ensure the Engineer's Quality Management system is in place for Construction Monitoring. • Ensure there is competent staff on site	Quality Management HR Management
Late approval of work	• Ensure the Engineer's Quality Management system is in place for Construction Monitoring. • Ensure there is competent staff on site	Quality, Communication and HR Management
Misalignment of project objectives between consultants and client, miscommunication	• Ensure good scope definition and project conceptualisation at planning stage • Ensure proper communication channels	Scope, Communication, Integration and Stakeholder

Reason for failure (at construction stage)	Good Practice required from the engineer to avoid similar failure	Knowledge Area of Skill required to mitigate the failure[1]
between design and construction departments / contractors	• Perform integrated change control • Have a stakeholder management plan and control stakeholder engagement	Management
Dissatisfaction on the part of the sponsors	• Ensure there is constant communication between consultant and client, and that all project deliverables are signed off by client at all stages. • Have a stakeholder management plan and control stakeholder engagement • Have a quality management system in use.	Communication, Scope, Risk, Stakeholder and Quality Management

[1]Aligned with the PMBOK® Guide Knowledge Areas

Again, it can be seen from **Table 2-4** that the good practice required to avoid the types of failures listed from the forgoing studies can be solved or avoided by effectively applying project management skills that are aligned with one or more of the ten PMBOK® Guide Knowledge Areas.

This observation is supported by Mendez (2003) who identified the top 7 challenges that are faced in most consulting projects as listed in **Table 2-5**.

Table 2-5: Top seven challenges of consulting (Mendez, 2003:3)

	Top 7 Challenges of Consulting
1	Managing and satisfying client expectations
2	Defining and controlling the scope of the work
3	Estimating consulting projects
4	Coping with scarce resources
5	Communicating effectively
6	Dealing with resistance (and politics)
7	Getting appropriate management support

The author then showed a matrix (**Table 2-6**) documenting the PMBOK® Guide Knowledge Areas and /or processes that are most closely related to the seven challenges. In the table, the cells marked with an “A” represent the knowledge areas that mostly “apply” to handle the challenge.

Table 2-6: **Consulting risk / challenge and most related PMBOK 2000 knowledge area (Mendez, 2003:6)**

	Risk / challenge						
PMBoK 2000 KNOWLEDGE AREAS	**1. Managing and satisfying client expectations**	**2. Defining and controlling the scope of the work**	**3. Estimating consulting projects**	**4. Coping with scarce resources**	**5. Communicating efficiency**	**6. Dealing with resistance (and politics)**	**7. Getting appropriate management support**
Project Integration Management	A	A		A	A	A	A
Project Scope Management	A	A					
Project Time Management			A	A		A	
Project Cost Management			A	A			A
Project Quality Management	A						
Project Human Resources Management				A	A		A
Project Communication Management	A			A	A	A	
Project Risk Management	A	A	A	A	A	A	A
Project Procurement Management				A			

The author observed that risk management is significantly important in consulting projects, and that for every risk or challenge there are at least two related knowledge areas, and one or more processes from within the related knowledge areas that can be used to mitigate and or address the identified risks or challenges.

The author further stated that in addressing these issues and others that might be encountered in a consulting environment, the PMBOK® Guide Knowledge Areas and processes serve as a “toolbox” providing a set of techniques to manage these situations.

The foregoing studies have discussed the reasons why most projects fail. As discussed in **Table 2-4** and avowed by Mendez (2003), it can be concluded that the failures identified from the various studies can be solved or avoided by effectively applying project management skills and good practices that are aligned with one of more of the PMBOK® Guide Knowledge Areas.

In a different study, Hawley and Frauenhoffer (1996:55) identified the following as the critical success factors for the success of any project in technical consulting (**Table 2-7**). The knowledge area of the skill required to achieve success is shown in the right-hand side column.

Table 2-7: Critical success factors (Hawley and Frauenhoffer, 1996:55) and the skills required to perform the tasks

Critical Success Factor	**Knowledge Area of Skill(s) required to perform the task(s)** [2]
Select technology	
Lead the team	Communication, Stakeholder, HR
Deliver the work	Time, HR
Involve the client	Communication, Stakeholder
Control time and money	Time, Cost, Risk
Ensure quality	Quality
Improve the professional team	HR
Resolve issues or conflict	HR, Communication
Measure production versus clients' requirements	Time, Cost, Quality

[2] *Aligned with the PMBOK® Guide Knowledge Areas*

Conclusion

There are various competencies an engineer requires and critical success factors for the delivery of a successful project in technical consulting. It can be seen from **Table 2-2** (based on ECSA scope of services), **Table 2-3** (based on SACPCMP scope of services), **Table 2-4** (from studies by various authors), **Table 2-6** (Mendez, 2003) and **Table 2-7** (Hawley and Frauenhoffer, 1996), that the good practice required to execute engineering work to produce the expected deliverables and to meet the critical success factors in technical consulting can

be achieved by applying project management skills that are contained in one of the ten PMBOK® Guide Knowledge Areas.

2.3.3 Project management methodology for the consulting engineering industry

Organisations are learning the value of customising project, programme and portfolio management processes to fit their specific objectives, practices and environments. Creating such a documented approach, called a methodology, allows the organisation to standardise its project management practices company-wide and to increase the effective and efficient use of resources (PMI, 2014b). Labuschagne and Steyn (2010:70) define a methodology as “a set of methods, processes, and practices that are repeatedly carried out to deliver projects on time and within budget, while meeting all specifications and expectations.”

A methodology incorporates and integrates knowledge about the way in which an organisation conducts its business (including requirements and processes). For practitioners, a methodology provides consistency for both project managers and team members across the organisation. Common tools, templates and other resources help the project manager guide the project to success (PMI, 2014b).

Limited literature is available on the status of project management, project management methodologies, and performance of consulting projects in the engineering environment (Labuschagne & Steyn, 2010:70). In a research project to explore the characteristics of a project management methodology that is currently used in the consulting engineering industry in South Africa, Labuschagne and Steyn (2010:70) point out that there is need to define and implement a project management methodology that specifies the steps and tasks that are required to manage consultation-type projects in a consistent manner. The authors concluded that:

- *Respondents were in positive agreement that a lack of project management knowledge and experience are the pressing and*

challenging issues when applying a project management methodology in the South African consulting engineering industry,

- *Respondents were in full agreement that the typical life cycle phases required for consulting engineering projects are initiation, planning, execution and close-out phase.*

Details of the proposed methodology are given in **Table 2-8**.

2.3.4 Conclusion

The scope of services provided by engineers in South Africa has been discussed. In order to achieve the typical deliverables for each of the standard and additional services, some of the skills and good practice that are required by engineers can be categorised into one or more of the ten knowledge areas of the PMI's PMBOK® Guide. Similarly, for those projects done under the SACPCMP Guideline scope of services, the skills and good practice that are required to achieve the deliverables can also be categorised into one or more of the ten knowledge areas of the PMI's Project Management body of Knowledge.

A number of previous studies that have been carried out to determine the factors that lead to project failures have concluded that the good practices required to avoid the types of failures investigated are aligned with the ten PMBOK® Guide Knowledge Areas. Although literature on existing project management methodologies for the consulting engineering industry is limited, the methodology proposed by Labuschagne and Steyn (2010) suggests that the ten PMBOK® Guide Knowledge Areas are core to the project execution phase. It can therefore be concluded that project management skills are necessary requirements that engineering firms need to practice in order to deliver successful projects.

Table 2-8: Details of proposed project management methodology (Labuschagne and Steyn, 2010:76)

	Project Initiation	Project Planning	Project Execution	Project Close-out
Deliverables	**PROJECT INITIATION FORM** ➢ General business case ➢ Project description ➢ Project time line ➢ Project cash flow ➢ Assumptions ➢ Dependencies ➢ Potential Risks ➢ Governance team ➢ Requirements for next phase ➢ Sign-offs **BUSINESS CASE** **FEASIBILTY STUDY** ➢ SWOT Analysis ➢ HAZOP **TERMS OF REFERENCE** **HR** ➢ Appoint Project team ➢ Safety appointments ➢ Legal appointments **SET UP PROJECT OFFICE** **PERFORM PHASE REVIEW**	**CREATE PROJECT PLAN** ➢ WBS ➢ Resource training ➢ Schedule ➢ Create resource plan o Strategy o Organogram ➢ Roles and Responsibilities ➢ Create Financial plan o Strategy o Budget o Cash Flows ➢ Create Quality Plan ➢ Create risk plan ➢ Strategy ➢ Risk Assessment ➢ Risk log ➢ Mitigation plan ➢ Create communications plan o Strategy o Stakeholders o Meeting schedule ➢ Create procurement plan o Strategy **CONTRACT SUPPLIER AND SUB-CONTRACTORS** ➢ Supplier audits **PERFORM PHASE REVIEW**	**BUILD DELIVERABLES, MONITOR, AND CONTROL** ➢ Perform time management ➢ Perform cost management ➢ Perform quality management ➢ Perform change management ➢ Perform risk management ➢ Perform procurement management ➢ Perform acceptance management ➢ Perform communication management	**PERFORM PROJECT CLOSURE** **REVIEW PROJECT COMPLETION**
Signoffs	Client Project sponsor Business unit manager Project manager	Client Project sponsor Business unit manager Project manager	Client Project sponsor Business unit manager Project manager	Client Project sponsor Business unit manager Project manager

2.4 Project management maturity models

2.4.1 Introduction

In an environment where projects are increasingly becoming fundamental components of effective operations, improving the success of project management has become the subject of much scrutiny. One of the most widespread approaches to improving project management performance that has gained currency over the past 15 years is the use of “project management maturity models” (Brookes, Butler, Day & Clark, 2014:232). Project management maturity models (PMMMs) have now become an established part of many formal project management bodies of knowledge and an accepted route to improve project management practice (Brookes et al., 2014:233). Despite considerable criticism PMMMs provide one comprehensive approach to strategically further develop an organisation’s project management structures (Albrecht and Spang 2014:285).

2.4.2 Project management

PMBOK® Guide (2013:3) defines a project as a temporary endeavour undertaken to create a unique product, service or result. The temporary nature of projects indicates a definite beginning and end. This can be contrasted from a routine set of activities or daily operations which are intended to be continuous processes without a planned end (Ofori, 2013:16)

Kerzner (2006:2) states that:

A project can be considered to be any series of activities and tasks that:

- *Have a specific objective to be completed within certain specifications*
- *Have defined start and end dates,*
- *Have funding limits (if applicable),*
- *Consume human and non-human resources (i.e. money, people, equipment)*

Project management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements (PMBOK® Guide, 2013:5). Kerzner (2006:3) defines project management as the planning, organising, directing and controlling of company resources for a relatively short-term objective that has been established to complete specific goals and objectives.

Holmes, Robert and Walsh (2005:1) define project management as follows:

> *"…management is the process or personnel responsible to plan, control, guide, direct, train and oversee the use of resources needed to achieve the goals of a business in a timely manner. Project management is a specific subset of the general process or organisation and follows the same basic definition, with the added proviso that project management is bound in time and scale"*

2.4.3 Project management bodies of knowledge

Bodies of knowledge circumscribe the knowledge areas that professionals are expected to master and apply to their profession (Cleland and Ireland, 2010). Bodies of knowledge have been codified into formal documents since 1983 and continue to evolve with the profession. Several professional organisations have developed different versions of a project management body of knowledge.

The Project Management Institute (PMI) in Newtown Square, Pennsylvania, has been the leader in developing a project management body of knowledge. Other organisations, such as the International Project Management Association (IPMA) in Switzerland, the Association for Project Management (APM) in England, the American Society for the Advancement of Project Management (ASAPM) in the United States, and the Australian Institute for Project Management (AIPM) in Australia, have also developed bodies of knowledge. All organisations refer to their respective bodies of knowledge as standards.

PMI's project management body of knowledge is the most widely recognised and used. It is officially referred to as A Guide to the Project Management Body

of Knowledge, or PMBOK® Guide (Cleland and Ireland, 2010). The 2013 edition defines the body of knowledge in ten areas. The PMBOK® Guide is probably the most popular of several available project management standards (Pretorius, Steyn & Jordaan, 2012:4). This is confirmed by Wideman (1998) as quoted by Smith (2002:25) who stated that the "Project Management Body of Knowledge (PMBOK® Guide) published by the Project Management Institute (PMI) represents the knowledge and practice that is generally accepted and unique or nearly unique to the field of project management."

Review of the literature reveals that the PMBOK® Guide is the most relevant and widely used project management standard and therefore it is the one that was explored further.

2.4.4 Project management knowledge areas of the PMBOK® Guide

The PMBOK® Guide is a set of ethics and standards developed by the Project Management Institute (PMI) for the project management profession. The PMBOK is an inclusive term that describes the sum of knowledge within the profession of project management (Sonnekus and Labuschagne, 2003:5). There are ten knowledge areas that are divided into two main categories, namely core functions (scope, time, cost and quality) and facilitating functions (human resource, communication, risk, procurement and stakeholders) with integration management tying them all together.

The knowledge areas are subdivided into processes. There are 47 project management processes that are mapped onto the five project management process groups which are initiating, planning, executing, monitoring and controlling and closing and the ten PMBOK® Guide Knowledge Areas. This is summarised in **Table 2-9.**

Table 2-9: Project Management Process Group and Knowledge Area Mapping (PMBOK® Guide, 2013:61)

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	**Planning Process group**	**Executing Process Group**	**Monitoring & Controlling Process Group**	**Closing Process Group**
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work	4.4 Monitor and Control Project Work 4.5 Perform Integrated Change Control	4.6 Close Project or Phase
5. Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
6. Project Time Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Resources 6.5 Estimate Activity Durations 6.6 Develop Schedule		6.7 Control Schedule	
7. Project Cost Management		7.1 Plan Cost Management 7.2 Estimate costs 7.3 Determine Budget		7.4 Control Costs	
8. Project Quality Management		8.1 Plan Quality Management	8.2 Perform Quality Assurance	8.3 Control Quality	
9. Project Human Resource Management		9.1 Plan Human Resource Management	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
10. Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.5 Control Communications	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses		11.6 Control Risks	
12. Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	12.4 Close Procurements
13. Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Management	13.3 Manage Stakeholder Engagement	13.4 Control Stakeholder Engagement	

The definition of each process group is given hereunder.

Initiating Process

The Initiating Process Group consists of those processes performed to define a new project or a new phase of an existing project by obtaining authorisation to start the project or phase (PMBOK® Guide, 2013:54)

Planning Process

The Planning Process Group consists of those processes performed to establish the total scope of the effort, define and refine the objectives, and develop the course of action required to obtain those objectives. (PMBOK® Guide, 2013:55)

Executing Process

The Executing Process Group consists of those processes performed to complete the work defined in the project management plan to satisfy the project specifications (PMBOK® Guide, 2013:57)

Monitoring & Controlling Process

The Monitoring and Control Process Group consists of those processes required to track, review and orchestrate the progress and performance of the project: identify any areas in which changes to the plan are required: and initiate the corresponding changes (PMBOK® Guide, 2013:57)

Closing Process

The Closing Process Group consists of those processes performed to conclude all activities across all project management process groups to formally complete the project, phase, or contractual obligation (PMBOK® Guide, 2013:57)

The Knowledge Areas are defined as follows:

Project Integration Management

Project integration management is the process that ensures various elements of the project are properly coordinated. Project and organisational success rely on integrating effective PM strategies with proper utilisation of PM techniques at different maturity levels. Topics such as project management integration, applications, processes, organisations, and project life cycle phases are included in this area (Kwak & Ibbs, 2002:151).

Project Scope Management

Project Scope Management includes the processes required to ensure that the project includes all the work required, and only the work required, to complete the project successfully. Managing the project scope is primarily concerned with defining and controlling what is and is not included in the project (PMBOK® Guide, 2013:5).

Project Time Management

Project time management ensures completing a project on time, which is one of the major challenges for any project manager. It includes activity definition and sequencing, duration estimation, schedule development, and schedule control (Kwak & Ibbs, 2002:152).

Project Cost Management

Project cost management ensures that the project is completed within the approved budget. Cost management is crucial because cost overruns are common resulting in serious cost problems during project execution. Project cost management includes resource planning, cost estimating, cost budgeting and control, earned value analysis, and depreciation and capital budgeting (Kwak & Ibbs, 2002:152).

Project Quality Management

Project quality management ensures that the project will meet or exceed all activities of the overall management function. It includes an overview of quality concepts, the cost of quality, statistical process control, variation and measurement, and quality improvement (Kwak & Ibbs, 2002:153).

Project Communications Management

Project communication management ensures timely and appropriate generation, collection, dissemination, storage, and disposition of project information. Open and clear communications are required among planners, implementers, and all levels of the organisation for project success. It includes having a communication plan, information distribution path, progress reporting,

and information sharing system for management and customers (Kwak & Ibbs, 2002:153).

Project Risk Management

Project risk management identifies, analyses, and responds to project risk. It includes defining, identifying, and quantifying risk; formulating risk mitigation strategies; and developing appropriate risk response and control processes (Kwak & Ibbs, 2002:153).

Project Procurement Management

Project procurement management ensures that goods and services from outside the performing organisations are acquired. It includes contract administration, contract risk, contract negotiations, configuration management, and contract termination (Kwak & Ibbs, 2002:153).

Project Stakeholder Management

Project stakeholder management includes the processes required to identify the people, groups or organisations that could impact or be impacted by the project, to analyse the stakeholder expectations and their impact on the project, and to develop appropriate management strategies for effectively engaging stakeholders in project decisions and execution (PMBOK® Guide, 2013:91).

2.4.5 Project management maturity

The Oxford Advanced Learner's Dictionary defines "maturity" as the state of being fully grown or developed (Pretorius et al., 2012:2). When this concept is applied to a project, it could imply a situation where an organisation has standards and procedures in place that could assist it in meeting its objectives. According to Pretorius et al. (2012:2), Andersen and Jessen (2002) concluded that an organisation is mature when it is able to deal perfectly with its projects.

Tarne (2007:1) describes project management maturity as the progressive development of an enterprise-wide project management approach, methodology, strategy and decision-making process. The author further states

that an appropriate level of maturity will vary for each organisation based on specific goals, strategies, resource capabilities, scope and needs.

Pennypacker and Grant (2003:5) write:

> *Project Management Maturity models (PMMM) provide a systematic means to perform benchmarking and hence are adding considerable value to present-day organisations. The maturity models provide an assessment framework that enables an organisation to compare its project delivery with best practice or against competitors, ultimately defining a structured route to improvement*

According to Jugdev & Thomas (2002:6), companies demonstrate behaviours that reflect their maturity levels. MMs identify project or organisational strengths and weaknesses and benchmarking information (Jugdev & Thomas, 2002:4).

Mullaly (2014:172) quotes Maier et al.:

> *Organizations are encouraged to use existing and well-known methods and practices to progress along the maturity scale. The assumption is that the more structured a process and the more transparent in terms of measurability of performance the better (Maier et al., 2012:146).*

2.4.6 Origin of maturity models

According to Jugdev and Thomas (2002), the PMMM has its origin in the Capability Maturity Model developed at Carnegie Mellon University in the USA between 1986 and 1993. Since then around 30 different models have been developed each addressing a specific business model or industry context (PMForum, 2008 as quoted by Brookes and Clarke, 2009:2). This proliferation of model variants and inclusion in both the APM and PMI Bodies of Knowledge demonstrate that PMMMs have now become an established part of documented practice. The utility of PMMMs has been promulgated by project management professional bodies as evidenced by the development of the

Organisational Project Management Maturity Model by the Project Management Institute. (Brookes et al., 2014:233)

2.4.7 PMMMs: Disparity in operationalisation

The maturity models that are available today and that cover project-related management processes can be divided into three approximate types relating primarily to the maturity of: project management processes, technical delivery processes, and the total organisation (Project Manager Today, 2002:3). They differ from one another in terms of both the scope of what is covered, and their central focus. This view is shared by Brookes and Clark (2009:2) who, in reviewing the current experience of the use of project maturity management models, observe that there are different ways in which the project management maturity models are conceptualised and these disparities include:

- their delineation of the 'maturity' construct,
- the project management knowledge areas they cover, and
- their scope.

In reviewing the literature, it is apparent that the definition and scope of each model is different in some way to the other models that have been developed.

2.4.7.1 Delineation of the 'maturity' construct

Andersen and Jessen (2003), as quoted by Brookes and Clark (2009: 2) started their investigation of project maturity in organisations with a review of the definition of what it is to be mature. Webster's Dictionary defines it as "being ripe or having reached the state of full natural or maximum development." In many respects, this is the only feature common across the range of models that have developed since the original (Brookes and Clark, 2009:2)

Most models identify a group of knowledge areas and a series of maturity levels. The responses to questions asked in each of the identified knowledge areas are then assessed as to the level of project management maturity they represent (Brooke and Clark, 2009: 3) Many models use the original Carnegie

Mellon maturity level definitions (**Table 2-10).** Although the definitions may vary, the 5 level approach is the one that has seen general acceptance.

Table 2-10: Stages of Maturity by Paulk et al. 1993 as quoted by Brooke and Clark (2009:3)

Stage of Maturity	Description
1) Performed	Unpredictable process that is poorly controlled and reactive
2) Managed	Project process is characterised but is often reactive
3) Defined	Characterised process for the organisation that is proactive
4) Quantitatively Managed	Process measured and controlled
5) Optimising	Process improvement focus

2.4.7.2 The project management knowledge areas

The knowledge areas are less consistent (Brooke and Clark, 2009:3). The approach described by Crawford (2006), as quoted by Brookes and Clark (2009:3) and Brookes et al. (2014:233), is to use the then nine knowledge areas identified in the PMBOK® Guide. Brookes and Clark (2009:4) and Brookes et al. (2014:233) observed that Kwak and Ibbs (2002) consider the then nine knowledge areas used by Crawford, but applied to each of the five parts of the project processes –initiating, planning, executing, controlling and closing.

2.4.7.3 The Scope

The scope of the different models is also variable. Some are much more focused on the project management processes, whereas others are much broader, taking in the entire organisation (Brooke and Clark, 2009:4). Organisational factors have an influence in the outcome of projects (PWC, 2004:3), suggesting that the broader organisational models are more appropriate (Brooke and Clark, 2009:4)

2.4.7.4 So which process should be adopted?

Pennypacker & Grant (2003:5) write that there are many dimensions of project delivery capability that can be assessed and improved as a result of project

management maturity benchmarking, and that the structure of the PMMM will determine the dimensions addressed, which dimensions include project management practices, operations, processes, knowledge areas, competencies, and phases.

Cooke-Davies (2004:4) wrote:

> *"The two models that have received the greatest attention in the research literature so far have been the Berkeley PM Process Maturity Model (Ibbs & Kwak,1997; Ibbs & Kwak, 2000; Kwak & Ibbs, 2000; Ibbs & Reginato, 2002) and the PM Solutions Project Management Maturity Model (Burns & Crawford, 2002; Pennypacker, 2002; Pennypacker & Grant, 2003). Like other project management maturity models, each of these assesses the maturity of processes derived from the Project Management Institute's (PMI) A Guide to the Project Management Body of Knowledge (PMBOK® Guide) (2000) areas...*"

The PMI's PMBOK® Guide is an excellent point of reference for starting an examination of project management capability. It is already an acceptable standard, and there is a great deal of "best practices" information in existence around the knowledge areas outlined in the document (Crawford, 2006:50). PMI's PMBOK® Guide (2000) describes those project management practices that are applicable to most projects most of the time (Cooke-Davis, 2004:6)

The foregoing discussion shows that the available project management maturity models cover different project-related management processes. The PMBOK® Guide-based model was used for this research. Its suitability is supported by Sonnekus and Labuschagne (2003:4) who acknowledge that the PMBOK® is one of several project management guides available but chose it as a standard in their study "*IT Project Management Maturity versus Project Success in South Africa*". Despite the concerns and cautions regarding their relevance, however, it would appear that standards – and particularly the knowledge areas of the PMBOK® Guide – are the predominant source of input for several current

maturity models (Mullaly, 2014:172). A PMBOK® Guide-based model was therefore used for this research.

2.4.8 Examples of Maturity Models

Practitioners in the field have developed many maturity models for project management (Holmes & Walsh, 2005). There are various maturity models that are based on the PMI's PMBOK® Guide. Two of the most common models are the PM Solution's PMMM and the IMSI Project Management Assessment Model. Other models briefly described in this chapter are MicroFrame's Self-Assessment Tool and Kerzner's Project Management Maturity Model.

2.4.8.1 PM Solutions' PMMM (Crawford, 2006)

PM Solutions developed the Project Management Maturity Model (PMS-PMMM) that consists of five maturity levels that have been defined by Software Engineering Institute (SEI) in the Capability Maturity Model (CMM) models. These maturity levels are:

- Level 1: Initial process,
- Level 2: Structured process and standards,
- Level 3: Organisational standards and institutionalised process,
- Level 4: Managed process, and
- Level 5: Optimising process.

Additionally, the model utilises the ten knowledge areas that are derived from the PMI's PMBOK® Guide. The knowledge areas are respectively project integration management, project scope management, project time management, project cost management, project quality management, project human resource management, project communications management, project risk management, and project procurement management and project stakeholder management (see **Figure 2-2**). PMS-PMMM is specifically designed to describe the organisation's project management effectiveness, or project management maturity (Crawford, 2006).

The project maturity model is depicted in **Figure 2-2** below:

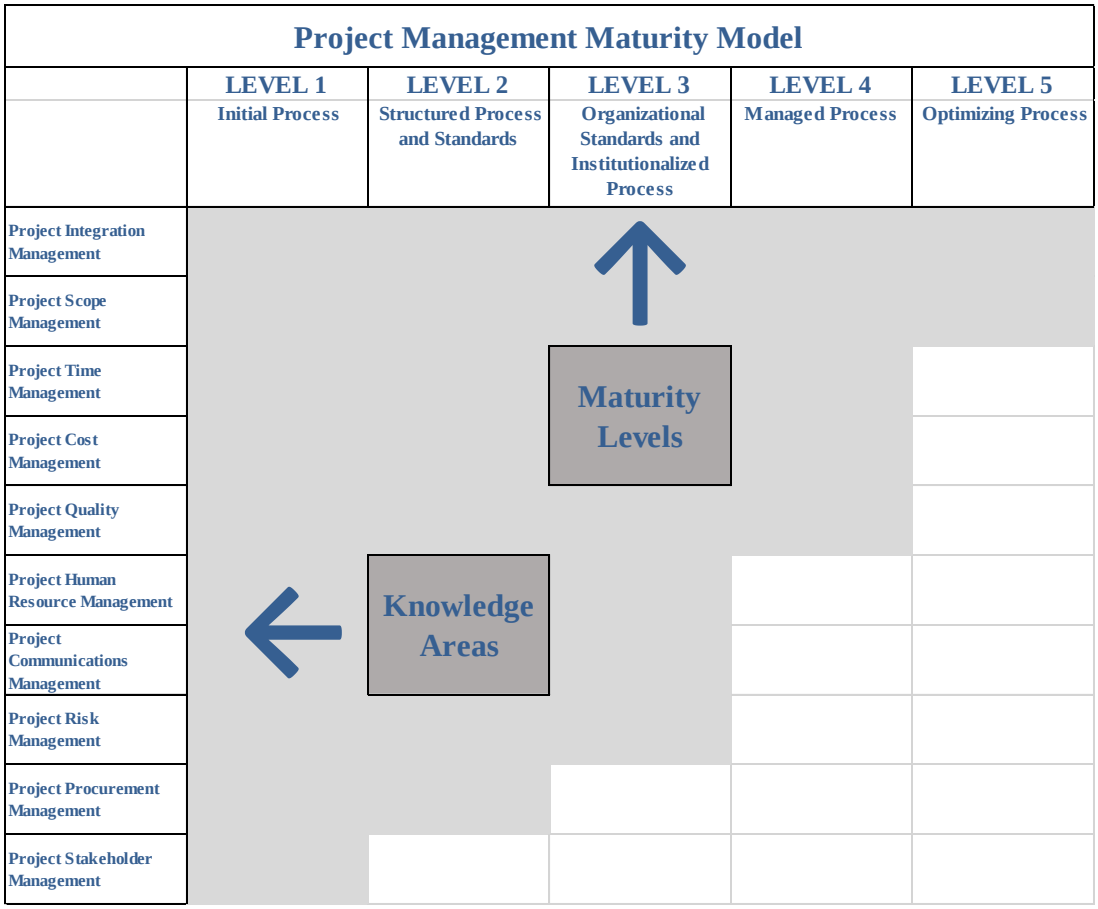

Figure 2-2: PM Solutions' Project Management Maturity Model (PMS-PMMM) – adapted from PM Solutions (2012)

2.4.8.2 The IMSI Project Management Assessment Model (Holmes & Walsh, 2005)

Integrated Management Systems Incorporated (IMSI) has examined a number of the candidate models, and from this research, and the collective experiences of its employees, IMSI has developed its own methodology for assessing the status of project management within a client organisation (Holmes & Walsh, 2005).

According to Holmes & Walsh (2005), IMSI's project management assessment model is a typical, five-step maturity model. In this model, level

1 is the beginning of the progression, generally characterised by a shared recognition of the organisational process being examined. Moving to Level 2 requires an organisation-wide adoption of a common vocabulary and the identification of standardised processes. Each maturity model describes the organisational characteristics necessary to achieve each different level, all ending at Level 5, wherein the organisation culture has fully embraced the process, optimised the process in its current state, and seeks to continually improve the process going forward. The IMSI assessment model looks at each of the project management Knowledge Areas and the enablers, critical elements and processes associated with them.

2.4.8.3 MicroFrame's Self-Assessment Tool (Sukhoo et al, nd:681)

According to Sukhoo et al (nd:681), Microframe Technologies together with Project Management Technologies, have developed and made available on the Internet a self-assessment tool for project management maturity with 50 multiple-choice questions. The result of this quick self-assessment is a ranking in one of the following five categories:

- Level 1 – Ad-hoc: the project management process is described as disorganised, and occasionally even chaotic. Systems and data processes are not defined. Project success depends on individual effort. Chronic cost and schedule problems.
- Level 2 – Abbreviated: some project management processes and systems are established to track cost, schedule, and performance. Underlying disciplines, however, are not well understood or consistently followed. Project success is largely unpredictable and cost and schedule problems are the norm.
- Level 3 – Organised: project management processes and systems are documented, standardised, and integrated into an end-to-end process for the company. Project success is more predictable. Cost and schedule performance are improved.
- Level 4 – Managed: detailed measures of the effectiveness of project management are collected and used by management. The process is

understood and controlled. Project success is more uniform. Cost and schedule performance conform to plan.

- Level 5 – Adaptive: continuous improvement of the project management process is enabled by feedback from the process and from piloting innovative ideas and technologies. Project success is the norm. Cost and schedule performance are continuously improving.

2.4.8.4 Kerzner's Project Management Maturity Model (Schiltz, 2003, extracted from Sukhoo et al, nd: 682)

Kerzner's maturity model defines five levels by which an organisation is ranked from insufficient project management processes to adequate project management processes leading to continuous improvement. These five levels are shown in the figure below and are described as follows:

- Level 1 – Common Language: the organisation recognises the importance of project management and the need for a good understanding of the basic knowledge on project management.
- Level 2 – Common Processes: at this level, the organisation recognises that common processes need to be defined and developed so that project success can be repeated.
- Level 3 – Singular Methodology: the organisation defines a single methodology for project management in order to take advantage of the associated synergistic effect.
- Level 4 – Benchmarking: the organisation recognises that process improvement is necessary to maintain competitive advantage.
- Level 5 – Continuous Improvement: at this level, the organisation evaluates the information obtained through benchmarking and decides how to improve.

2.5 Influence of maturity on project outcome

A number of studies have been conducted in South Africa to investigate how the success of IT projects related to the project management maturity of the organisation that executed the projects.

The maturity of an organisation provides a benchmark for the success of its operations (Sukhoo, Barnard, Eloff & Van der Poll, nd:680). In its survey to determine the current state of project management maturity in organisations across the world, PricewaterhouseCoopers (PWC) (2004:9), concluded that a higher project management maturity level will in most cases deliver superior performance in terms of overall project delivery and business benefits. According to Tarne (2007), research conducted by the Centre for Business Practices showed that as organisations advance in project management maturity, they realise measurable benefits and that organisations that improved maturity by one level saw significant performance benefits, especially in customer satisfaction. The research also reported improvements in schedule performance, cost performance, project quality and many other areas.

There is a correlation between the business process results and the maturity of a project-oriented system (Chmieliauskas, Buda, Stasiukynaite & Viliunas, 2006:1). The outcome is that organisations that improve their maturity execute projects more effectively. Simply put, the benefits derived from project management increase in proportion to how well project management processes are used (Holmes and Walsh, 2005:1). Mullaly & Thomas (2010), as quoted by Pretorius et al (2012:3) point out there seems to be a relationship between maturity and performance, but that no statistically significant correlations exist to prove it.

Cooke-Davis, 2004:7 writes:

> "*Various claims have been made about the benefits that organizations have obtained from using particular maturity models (Peterson, 2000; Rosenstock, Johnston, & Anderson, 2000; Suares, 1998). The implications are that mature organizations are able to:*

> • *Manage all the projects undertaken by an organization effectively (Suares, 1998);*
> • *Improve continually the performance of all projects undertaken by an organization (Peterson, 2000);*
> • *Improve dialogue between the project management community and an organization's top management (Peterson, 2000)."*

Jugdev and Thomas (2002), as quoted by Cooke-Davies (2004:7) examine maturity models from the viewpoint of four different resource-based models in order to assess whether or not the possession of a higher maturity level in project management confers a competitive advantage on an organisation. The research concludes that maturity models possess some but not all of the characteristics of a strategic asset and thus cannot, in and of themselves, confer competitive advantage.

On the other hand, in a study that was conducted by Pretorius, Steyn and Jordaan (2012:1) to determine how the project management maturity of organisations related to the success of projects in various industries that included engineering and construction, the outcome was different. The study failed to establish any correlation between the project management maturity of an organisation and the perceived outcome of the projects that it produces (Pretorius et al., 2012:9). They claim that higher PMM does not automatically lead to project success; projects can be successful despite the maturity level of the organisation. Brookes et al. (2014:234) note that whilst a number of theoretical benefits for the use of PMMMs have been espoused, and despite the widespread acceptance of PMMMs, there is an intriguing lack of empirical data available to understand their use in improving project management performance.

Maturity models are credited with increasing the awareness and visibility of project management but there is no sound research supporting their use as an improvement tool, or indicating that in their current form they are a means of realising strategic advantage (Jugdev and Thomas, 2002, as quoted by Mullaly 2014:171). A longitudinal study of maturity in organisations demonstrated no

credible link between maturity and organisational performance, and highlighted significant concerns about the challenges of sustaining organisational maturity over time (Mullaly, 2006 as quoted by Mullaly 2014:171). While there is undoubtedly a conceptual appeal to the use of maturity models and a belief that they should provide relevant and useful insight on improving project management capabilities, the current reality does not appear to align with assertions of value and relevance (Mullaly, 2014:171)

Brookes et al. (2014:234) add that, given the limited evidence to show that increased levels of project maturity result in improved project performance and the diversity in existing PMMM approaches, it is useful to reflect on the purpose of measuring project maturity by Crawford (2006), who provided an explanation of the usefulness of undertaking this activity:

> *The benefits of a structured assessment of project management maturity lie in setting direction, prioritising actions, and beginning cultural change rather than in understanding the current level at which an organization is performing. The emphasis is on "structured". It is important that the assessment itself be repeatable, provide consistent measurements and results, and provide for some degree of benchmarking with other organizations.*

There is no consensus that a higher project management maturity automatically leads to improved performance in terms of overall project delivery. There is, however, a general agreement that a higher project management maturity results in positive measurable benefits.

2.6 Impact of application of the ten PMBOK® Guide knowledge areas to project outcome.

The previous studies discussed in section 2.3.2 are again summarised in **Table 2-11** categorised by author. The second column lists the reasons identified for failure or critical factors that could affect project performance and the third column the corresponding knowledge area of the process in which enhanced skill is required to mitigate the failure. For each reason for failure, a project

management process is identified which, if applied by a competent project manager, would prevent the kind of failure noted. The corresponding knowledge area for the process is then noted in the last column.

Table 2-11 is depicted on the next page.

Table 2-11: Summary of reasons for project failure and the corresponding KA of the skill required to mitigate the failure

Author	Identified Reason for failure and/or critical factors that could affect project performance	Corresponding knowledge area of skill required to mitigate the failure[3]
Doloi and Lim (2007:13)	Detailed planning in project budget and cost control	Cost
	Project time planning and & schedule control	Time
	Individual or personnel	HR
	Establishment of project quality control	Quality
	Ability to perform the required tasks	HR
	Availability of comprehensive project information and specifications	Scope
	Competency of key personnel	HR
	Close relationship between project time and cost management,	Cost and time
	Project complexity	Cost and time
	Individual's experience in the construction industry	HR
	Allowance for project contingency	Cost
	Detailed WBS and project milestones are not clear and well defined.	Scope and time
Samuel (2007:3)	Cost management is not applied effectively	Cost
	Poor scope definition by the client as well as poor project conceptualisation and design,	Scope and integration
	High percentage of variation orders which places tremendous strain on project budgets	Scope, cost and risk
	Low contract price	Cost and risk
	Ignorance of usage of proper time planning processes	Time
	Failure as a result of poor project quality management	Quality
	Poor translation of the scope into design and documentation by the professional team	HR
Aiyetan (2010)	Late instructions, poor dimensional coordination by the consultant	Quality
	Late preparation of interim evaluations	Time and cost
	Late inspection and approval of work.	Quality
Labuschagne and Steyn (2010:70)	Project failures with respect to time and cost	Time and cost
	Misalignment of project objectives between consultants and client,	Scope and communication
	Miscommunication between design and construction departments / contractors,	Communication / stakeholder
	Absence of project management practices,	All or any of the knowledge areas
	Dissatisfaction on the part of the sponsors	Communication and stakeholder

[3]Aligned with the PMBOK® Guide Knowledge Areas

Table 2-12 shows the frequency of the corresponding knowledge areas in which the identified reason for failure falls. The totals for each knowledge area are shown in the last column.

Table 2-12: **Knowledge Areas that contain processes that cause project failures**

	Number of times the researcher cites the reason for failure which falls into the corresponding knowledge area.				
Knowledge area in which the identified reason for failure falls.	**Doloi and Lim (2007:13)**	**Samuel (2007:3)**	**Aiyetan (2010)**	**Labuschagne and Steyn (2010:70)**	**Frequency**
Integration	0	1	0	1	2
Scope	2	2	0	2	6
Time	4	1	1	2	6
Cost	4	2	1	2	9
Quality	1	1	2	0	4
Human Resources	4	1	0	0	5
Communication	0	0	0	3	3
Risk	0	1	0	0	1
Procurement	0	0	0	0	0
Stakeholder	0	0	0	1	1

From this analysis, the knowledge areas which contain the processes that are cited the most by the authors as causing project failures or shortcomings are Cost-, Time-, Scope-, HR-, and Quality management. Risk and procurement processes are not identified as causes of shortcomings in the delivery of projects. Stakeholder management was only introduced as a knowledge area in the 5th edition of the PMBOK® Guide in 2013, after the cited research projects had already been carried out.

This observation corroborates the results of a study conducted by Pretorius, Steyn & Jordaan (2012) to investigate the relationship between project management maturity and project success in engineering and construction

industries in Sothern Africa. Pretorius. Steyn & Jordaan (2012:10) concluded that the following PMBOK® Knowledge Areas correlate positively with project outcome:

- Integration management;
- Scope management;
- Time management;
- Cost management, and
- Human resources management

The study further concluded that Quality management, Communication management, Risk management and Procurement management knowledge areas did not have any significant correlation with project outcome. Scope-, time-, cost- and quality management are “core functions”, while human resource, communications and risk management are “facilitating functions” according to Pretorius, Steyn & Jordaan (2012:10). In the study, the majority of knowledge areas that were found to have a direct relationship with project outcome were “core functions”, and the bulk of the areas that had no significant correlation with project outcome were “facilitating functions” (Pretorius, Steyn & Jordaan, 2012:10). HR management (a facilitating function) and quality management (a core function) were the only exceptions in that the former correlates with project outcome whilst quality management does not.

2.7 Maturity levels – benchmark data

Benchmarking can be used to evaluate an organisation’s current operational procedures and methods. Benchmarking may be a tool in developing maturity criteria for any organisation that is tailoring a capability maturity model for its use (Cleland 2007). Cleland (2007) explained that benchmarking is a strategy for measuring organisational products, services, and organisational processes against top-of-the-line competitors and industry leaders. This measurement is accomplished to determine whether an organisation is using best-in-class practices for business operations and for development of new performance standards against which to evaluate the enterprise

PMMMs provide a systematic means by which to perform benchmarking and hence are adding considerable value to contemporary organisations. The maturity models provide an assessment framework that enables an organisation to compare its project delivery with best practice or against its competitors (Pennypacker & Grant, 2003:5).

In research to provide a cross-industry benchmark of PMM, Pennypacker & Grant (2003:6) start by making a review of prior benchmarking studies. They state that Levene, Bentley and Jarvis (1995) performed one of the first studies that reported results based on PMM benchmarking. Since then, a number of studies have been carried out to assess the PMM of organisations. Most of these studies have been carried out in the IT industry.

In their research, Pennypacker & Grant (2003) adopted the PM Solution's PMMM as the basis for the benchmark. The results of the research were that the majority of respondents indicated their organisations were relatively immature in terms of the PMMM, with nearly 67% indicating their organisations were operating at level1 or at level 2 while a notable portion of respondents indicated their organisations had reached level 3. Only 6.5% assessed their organisations to have reached level 5.

According to Brookes and Clark (2009:7), Cooke-Davies and Arzymanow (2003) performed a benchmarking study that explored variations in project management practice in 21 organisations across six industries. The empirical research was based on in-depth interviews with "knowledgeable project management practitioners". The results of the study are summarised in **Table 2-13.**

Despite the small sample size, it is demonstrated that there is variability between industries. The more established users of project management such as the engineering-based industries demonstrate a higher level of maturity.

Table 2-13: Maturity Level Scores (calculated from Cooke-Davies and Arzymanow,2003)

Industry (number of companies)	Maturity Level Score
Large pharmaceutical R+D (9)	2.97
Medium pharmaceutical R+D (6)	3.04
Telecommunications (5)	3.46
Defence (4)	3.90
Financial services (3)	3.66
Construction (2)	3.56
Petrochemical (2)	4.69

In the study that was conducted by Pretorius, Steyn and Jordaan (2012:11) to determine how the project management maturity of organisations related to the success of projects in various industries that included engineering and construction, the success rate in the engineering and built environment sector was compared to projects in the IT sector. In contrast, the study found a significant difference between the average percentage of completed projects that were successful in the South African IT sector and the South African engineering and construction industry. The organisations had an average perceived level of maturity of 2.88.

According to Pennypacker & Grant (2003:10), to make valid comparisons of PMM requires the use of a common PMMM, common assessment techniques, a common level of analysis, common analysis techniques and representative samples. The studies that have been cited rely on different maturity models. These differences preclude any valid comparison of results between these studies (Pennypacker & Grant, 2003:10). The research concludes by stating that with a standard model, future research will adopt a more standard approach to conducting benchmarking studies. In the interim, it remains important to continue benchmarking (Pennypacker & Grant, 2003:10).

Vester & Lazarus (nd:7) investigated the average maturities of different project-oriented companies and concluded that the average project management maturity for engineering consulting companies is 3.90.

2.8 Relationship between size of firm and project outcome

2.8.1 Categorisation of consulting engineering firms by size

As part of its bi-annual state of the industry survey, CESA regularly asks member firms to comment on the services offered by the association. Questions included in the survey pertain to: level of service from the Association as a whole, level of service from the Directorate and personnel, relevance and quality of services offered pertinent to the firms' sector(s) and suggestions for improvement.

Industry Insight (2013: 10) reveals that in the latest survey carried out between July – December 2013, it was established that the majority of the firms employ less than 20 people (49 percent), followed by 40 percent employing between 20 and 100 and 10,5 percent employing more than 100 people. Firms with less than 20 people, were demarcated as small, those with between 20 and 100 people as medium and with above 100, as large. For the purpose of this research the following demarcation of firm sizes was adopted:

- Micro: 1-5 employees
- Small: 6-20 employees
- Medium: 21-100 employees
- Large: >100 employees

2.8.2 Performance by different size firms

In a study to conduct an empirical investigation to explore the impact of PMMMs on improving project performance, Brookes et al. (2014:231) found out that large organisations are more likely to have higher levels of project management maturity than smaller organisations. However, no organisation was found to be operating at levels "4" or "5" of project management maturity.

Other research findings offer a different view. Pennypacker and Grant (2003: 9) conclude that there is not a statistically significant difference in overall management maturity between companies of varying size.

This chapter provided a review of literature on the background of the consulting engineering industry and uncovered the importance of project management in the industry. The methodologies used in the industry were then be explored in order to determine the most applicable model to use to measure the maturity of project management in the industry. The origin, types and assessment of the most common project management maturity models (PMMMs) were examined. The relationship between maturity and project outcome were explored, so is the relationship between the size of an organisation and the project outcome. The next chapter will explain the methodologies and procedures employed for the study. These included data collection, sampling (populations used) and the questionnaire design.

3 CHAPTER 3: THE DATA AND THE TREATMENT OF THE DATA

3.1 Introduction

This chapter provides an explanation regarding the methodologies and procedures employed for the study. These included data collection, sampling (populations used) questionnaire design and data analysis.

3.2 Research method

There are two types of processes that can be used for research namely quantitative and qualitative and these are discussed hereunder.

Table 3-1 shows the distinguishing characteristics of the quantitative and qualitative methods.

Table 3-1: Distinguishing characteristics of quantitative and qualitative approaches (Leedy & Ormrod, 2010:96)

Question	Quantitative	Qualitative
What is the purpose of the research?	• To explain and predict • To confirm and validate • To test theory	• To describe and explain • To explore and interpret • To build theory
What is the nature of the research process	• Focused • Known variables • Established guidelines • Predetermined methods • Somewhat context-free • Detached view	• Holistic • Unknown variables • Flexible guidelines • Emergent methods • Context-bound • Personal view
What are the data like, and how are they collected?	• Numeric data • Representative, large sample • Standardised instruments	• Textual and /or image –based data • Informative, small sample • Loosely structured or non-standardised observations and interviews
How are data analysed to determine their meaning?	• Statistical analysis • Stress on objectivity • Deductive reasoning	• Search for themes and categories • Acknowledgement that analysis is subjective and potentially biased • Inductive reasoning
How are the findings communicated?	• Numbers • Statistics, aggregated data • Formal voice, scientific style	• Words • Narratives, individual quotes • Personal voice, literary style

According to Leedy and Ormrod (2010:95) the intent of quantitative research is to establish, confirm, or validate relationships and to develop generalisations that contribute to existing theories. Qualitative research is sometimes exploratory in nature and may be used to build theory from the ground up. **Table 3-2** summarises the distinguishing characteristics of quantitative and qualitative approaches.

Maturity models are qualitative in nature as they seek to describe an organisation's level of maturity in using project management processes. Maturity models define five levels by which an organisation is ranked from insufficient project management processes (Level 1) leading to continuous improvement (Level 5). Examples of the ranking are shown in **Table 3-2**.

Table 3-2: Maturity ranking of selected models (Extracted from Sukhoo et al., nd:681-684)

	Assessment Model		
Level of maturity	**MicroFrame's Self-Assessment Tool**	**(PM)2 Maturity Assessment Methodology**	**Kerzner's PMMM**
1	Ad-hoc	Ad-hoc	Common language
2	Abbreviated	Planned stage	Common processes
3	Organised	Managed stage	Singular methodology
4	Managed	Integrated stage	Benchmarking
5	Adaptive	Sustained stage	Continuous improvement

The questionnaire used for this study was sourced from a study conducted by Sukhoo et al. (nd), to determine software project management maturity in Mauritius. Adjustments were made to the questionnaire to include Stakeholder Management, the tenth PMBOK® Guide Knowledge Area introduced in the fifth edition. A sample of the questionnaire is found in **Appendix 1**.

3.3 Data collection procedure

Although the postal method has the advantages that it is the least expensive of all survey methods and provides the greatest possibility of anonymity, the lack of control over responding counts to its disadvantage.
Zikmund (2003), as quoted by Moyo (2010:77), advocates the use of email and internet surveys despite the drawbacks of lack of connectivity or lack of internet access for the following reasons:
For email surveys:

- Allow for speedy distribution;
- Lower distribution and processing costs;
- Have a faster turnaround time;
- Respondents are more candid via email than in person or on the telephone;
- More flexible

For internet surveys:

- Speedy and cost effective, and are
- Visually appealing

Welman and Kruger (1999:153) as quoted by Smith (2002:63), concur that electronic mail results in improved response rate as it is considered to be the preferred way of modern communication in most modern organisations and that the use of electronic mail provides the opportunity to develop an on-line (computer-based) questionnaire that is user-friendly and less time-consuming for respondents to complete.

The survey for this research was carried out in two main stages;

Stage 1 Distribution of the pilot questionnaire to a selected few project managers and receiving feedback which was incorporated in the final questionnaire; and

Stage 2 The actual survey.

The survey was distributed via internet using a research instrument by LimeSurvey which was made available by Nelson Mandela Metropolitan University's ICT Services.

3.4 Sample size and population

There are approximately 520 firms registered by CESA. The Sample size for a finite population (known target population) can be determined with the help of the Krejcie and Morgan Table of determining sample size for finite population. From the Krejcie and Morgan Table given in **Appendix 2**, the sample size required for a confidence level of 95% and a margin of error of 5%, is 221.

3.5 Development and construction of the research questionnaire

This section describes how the questionnaire was constructed and how it was developed.

3.5.1 Construction of the research questionnaire

The research questionnaire was divided into the following parts:

Part 1:	Details of the respondent's organisation,
Part 2:	Project retrospection – assessing the perceived success of the recently completed projects
Part 3:	Project Management Maturity – questions on PM Processes

3.5.2 Pilot questionnaire

According to Smith (2002:66), Welman and Kruger (1999:146) strongly recommended that a survey questionnaire be tested on a small group of individuals who are representative of the same population for which it is intended. The purpose of such a study is:

- To detect possible flaws in the measurement procedures (such as ambiguous instructions and inadequate time limits, and
- To identify unclear and ambiguously formulated items

Moyo (2010:74-75), affirms that the pilot study's questionnaire is to ensure that the questionnaire:

- Was properly phased;
- Could be answered within a reasonable period without causing "respondent fatigue" or boredom;
- Was easy to understand, and
- Did not have unforeseen problems such as content, structure or format which if uncorrected would result in big data losses in the larger study.

A pilot study questionnaire was prepared and sent to three project managers, who all successfully completed the pilot study questionnaire. The main comments received were that:

- It took them between 12 and 15 minutes to complete;
- The survey could take long for respondents who are not familiar with the PMBOK® Guide terminology and processes.
- Question 1 in Part 2, which asked respondents to give details of projects completed by their organisations, could be difficult to answer for some respondents who may not know or have access to organisation-wide statistics. This comment was accepted and the question was re-phrased to reflect performance of projects handled by the respondent.

A sample of the questionnaire is given in **Appendix 1**.

This chapter outlined the methodologies and procedures employed for the study. These included data collection, sampling (populations used) and questionnaire design. The next chapter presents the results of the survey and analysis of the data.

4 CHAPTER 4: THE RESULTS AND TESTING THE HYPOTHESES

This chapter presents the results and the analysis of the survey data.

4.1 Gathering the data

The survey questionnaire was sent to industry colleagues known to the researcher and was also distributed by CESA. A total of 63 responses were received of which only 41 were complete. The incomplete responses were analysed to see why there were so many of them.

The questionnaire was divided into three parts. Part 1 and Part 2 consisted of six questions. Part three required the respondent to first understand the definitions of the different Project Management Maturity levels. As such, the first section of Part 3 comprised a definitions table (362 words). All of the incomplete surveys were not completed beyond this point. Since the survey was anonymous it was not possible to contact the respondents to find out the reasons for failing to complete the survey. The most probable reason is that the respondents did not have enough time to read through the definitions before going through the 47 questions that followed.

4.2 Data from survey

4.2.1 Response rate

Sixty-three responses were received, of which twenty-two were not fully completed. The incomplete surveys were removed from the data analysis. This meant that 41 usable responses were used in the final analysis. The response rate of the study is 19%. According to Crafford (2007), as cited by Moyo (2010), contemporary survey response rates range from as little as 7% to as much as 40% in general. As such, comparing the study response rate of 19% with the abovementioned contemporary response rates it would seem that the study

response rate is adequate for the hypothesis tests to be conducted satisfactorily.

4.2.2 Distribution of respondents

The survey was sent to respondents who practice in the consulting engineering field. The respondents were asked to specify the size of their firms, and the results are as follows:

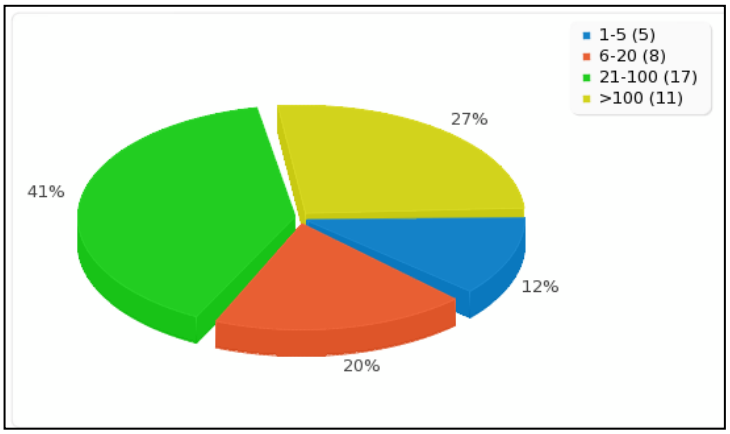

Figure 4-1: Distribution of respondents by firm size

Table 4-1: Distribution of respondents by firm size

Size of firm	Count	%
1 – 5 (micro)	5	12.20%
6 – 20 (small)	8	19.51%
21 – 100 (medium)	17	41.46%
>100 (large)	11	26.83%

The majority of the respondents work for organisations that employ between 21 and 100 people. Only five respondents work for the micro (1-5 people) firms. This could be because the respondents who received the survey were not pre-selected on the basis of the size of organisations in which they work. There is also a chance that there are respondents from the same firm who participated in the survey.

4.2.3 Firms with Project Management Offices

Respondents were asked to state whether or not the organisations they worked for had a formal project management office.

Of the 41 respondents, 19 of them (46.34%) work in organisations that have a formal Project Management Office (PMO) and 22 in organisations that do not have a PMO. The demarcation by size of firm is as follows:

Table 4-2: Firms with PMOs

Size of firm	**With PMO**		**Without PMO**	
	Count	**%**	**Count**	**%**
1 – 5 (micro)	1	20%	4	80%
6 – 20 (small)	2	25%	6	75%
21 – 100 (medium)	7	41%	10	59%
>100 (large)	9	82%	2	18%
Overall	**19**	**46%**	**22**	**54%**

The micro firms (1-5 people) generally do not have PMOs and 82% of the large organisations have a PMO.

4.2.4 Project success rates

Respondents were asked to state the number of projects that they have completed within the past 12 months and to state whether they were successful, challenged or failed. The results are as shown in Tables 4-3 and 4-4.

Table 4-3: Project success counts

Size of firm	**Projects Completed**	**Successful**	**Challenged**	**Failed**
1 – 5 (micro)	19	12	6	1
6 – 20 (small)	35	27	8	0
21 – 100 (medium)	73	40	31	2
>100 (large)	53	37	15	1
Overall	**180**	**116**	**60**	**4**

Table 4-4: Project success rates

Size of firm	Projects Completed	Successful	Challenged	Failed
1 – 5 (micro)	19	63%	32%	5%
6 – 20 (small)	35	77%	23%	0%
21 – 100 (medium)	73	55%	42%	3%
>100 (large)	53	70%	28%	2%
Overall	**180**	**65%**	**33%**	**2%**

A total of 180 projects were completed by the respondents within the past 12 months, and 65% of these were perceived as successful, 33% as challenged and only 2% were perceived to have failed. The success percentage is much higher, and the failure percentage low, when compared to the PMSA (2013:107) results which indicated a perceived success rate of 47% and failure rate of 17%. The PMSA (2013) figures compare well with figures from Pretorius et al. (2011). In investigating project management maturity and project management success in the engineering and construction industries, Pretorius et al. (2011:1) reported that 46% of respondents in their study had perceived their projects to be a success, 36% to be challenged and 18% as failures.

The success rate perceived in this study is much higher and the failure rate a great deal lower compared with the other studies cited above. This could be because the questionnaire asks for rating of projects that were completed within the last 12 months. It does not distinguish between:

- projects that went through all six stages from inception to construction,
- construction projects only, and
- projects that were limited to carrying out of studies or reports only.

Some projects undertaken by consulting engineering firms require production of documentation only such as feasibility studies. Lateness, poor quality of a document (which can be corrected by revisions) and cost (which can be

negotiated as the project proceeds) are often overlooked when judging the success of such a desk project. In a full cycle project, the success of a project tends to be measured more by completion of construction by the contractor. The success or failure of a completed project is often attributed to the contractor, contrary to the fact that the consultants are involved in all stages (as illustrated previously in **Figure 2-1**)

4.2.5 Perceived levels of maturity

Respondents were asked to state what they think is the level of project management maturity of their organisations. The perceived maturity levels are shown in **Table 4-5** and **Figure 4-2.**

Table 4-5: Perceived maturity level (for all firm sizes)

Maturity level	Count	%
1	1	2.44%
2	10	24.39%
3	14	34.15%
4	14	34.15%
5	2	4.88%

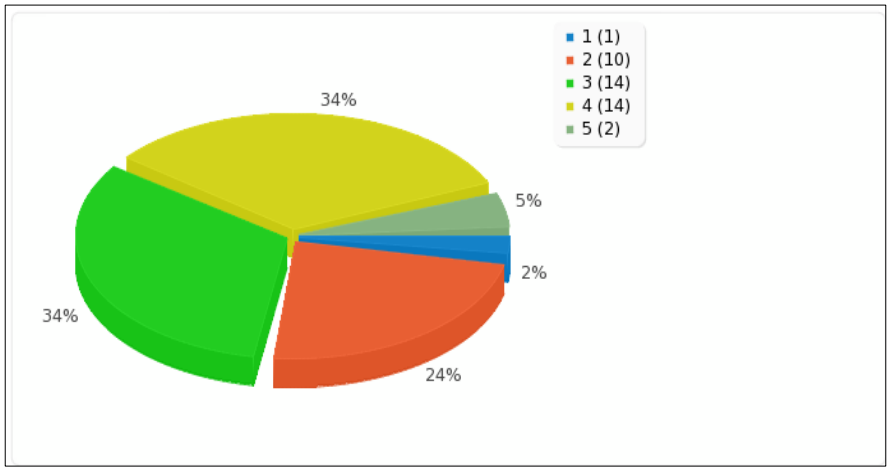

Figure 4-2: Perceived maturity level (for all firm sizes)

Thirty four percent of respondents perceive their project management maturity to be at level 4, 34% at level three and 24% at level two. Only 5% perceive their level at 5. The average perceived maturity of all respondents is 3.15.

The perceived maturity levels per firm size category are shown in **Table 4-6.** The perceived maturity levels range from 2.00 for micro firms to 3.73 for large firms. Small and medium firms have relatively similar maturity levels at 3.13 and 3.12 respectively.

Table 4-6: Perceived maturity level by firm size

	Count per Size of firm			
Perceived Maturity level	1-5	6 – 20	21 – 100	>100
1	1	0	0	0
2	3	1	4	2
3	1	6	7	0
4	0	0	6	8
5	0	1	0	1
	2.00	**3.13**	**3.12**	**3.73**

4.2.6 Actual levels of maturity

According to Sonnekus and Labuschagne (2003:13), the maturity of an organisation is the average of the maturity of the ten knowledge areas, where the average of a specific knowledge area is determined by the processes within that knowledge area. **Table 4-7** shows a summary of the maturity for each of the knowledge areas against the different firm category.

The average maturity level for all consulting engineering firms is 3.20. The average for the core functions (scope. time, cost and quality) is 3.38 and that of the facilitating functions is 3.06.

Table 4-7: Actual levels of maturity

		Firm Category					
		1 - 5	6 - 20	21 - 100	>100	Average maturity per Knowledge Area (1-5)	
		Micro	Small	Medium	Large		
	Integration	2,04	3,28	3,34	3,56	3,21	
Core Functions	Scope	2,43	3,19	3,41	3,38	3,25	3.38
	Time	2,76	3,27	3,35	3,75	3,34	
	Cost	2,8	3,13	3,35	3,64	3,32	
	Quality	3,07	3,71	3,51	3,85	3,59	
Facilitating Functions	HR	1,93	2,88	3,16	3,21	2,97	3.06
	Communication	2,65	3,31	3,37	3,25	3,24	
	Risk	2,17	2,52	2,87	3,2	2,73	
	Procurement	2,7	3,5	3,34	3,43	3,29	
	Stakeholder	2,45	3,22	3,19	3,3	3,09	
	Average maturity per firm category	**2,50**	**3,20**	**3,29**	**3,46**	**3,20**	

4.2.6.1 Perceived vs Actual Maturity Levels

Table 4-8 shows the perceived maturity levels which are compared with the actual **maturity levels.**

Table 4-8: Perceived vs actual maturity levels

Size of firm	Perceived maturity level	Actual maturity level
1 - 5 (micro)	2.00	2.50
6 - 20 (small)	3.13	3.20
21 - 100 (medium)	3.12	3.29
>100 (large)	3.73	3.46
Overall	**3.15**	**3.20**

Respondents from the micro, small and medium firms perceive their organisations to have lower levels of maturity than they actually have. The large firms have a lower maturity level than what the respondents think they have.

4.2.7 Maturity of Knowledge Areas

The maturity levels of the different knowledge areas are discussed hereunder.

4.2.7.1 Project Integration Management

The maturity of integration management is close to the average for the consulting engineering industry (which is 3.20).

Table 4-9 shows the maturity of the individual processes that make up integration management.

Table 4-9: Maturity of integration management processes

Process	**Maturity level**
a. Initiation	3,29
b. Project Plan Development	3,12
c. Direct and Manage Project Work	3,37
d. Integrated Change Control	3,07
e. Project / Phase Close-out	3,20
Average	**3,21**

Integrated change control has the lowest maturity level than the other processes. Organisations are most proficient in the “direct and manage project work” process than in the other processes.

The bigger organisations are more proficient in integration management than the smaller firms (**Table 4-10**)

Table 4-10: Maturity of integration management by firm sizes

Size of firm	**Maturity level (1-5)**
1 – 5 (micro)	2,04
6 – 20 (small)	3,28
21 – 100 (medium)	3,34
>100 (large)	3,56

4.2.7.2 Project Scope Management

The average maturity of scope management (3.25) is above the average for the consulting engineering industry (which is 3.20), which indicates that respondents are performing better in scope management than in other knowledge areas. This could be due to the fact that scope management is treated with high priority given that this is a knowledge area that has to be considered at an early stage, as well as throughout the whole project cycle. An incorrectly formulated project scope will certainly have major impacts on subsequent phases of the project (Sukhoo et al., nd:678). Therefore, it is imperative to carefully determine the appropriate scope so as to minimise the risk of the project getting off track during later stages.

Table 4-11: Maturity of scope management processes

Process	**Maturity level**
a. Scope Management Planning	2,95
b. Requirements Collection	3,17
c. Scope Definition	3,56
d. Create WBS	3,39
e. Scope Control	3,20
Average	**3,25**

Table 4-12 shows the average maturity values for scope management for each firm category. Contrary to expectation, results show that the level of maturity for large organisations is smaller than the level for the medium organisations.

Table 4-12: Maturity of scope management by firm sizes

Size of firm	**Maturity level (1-5)**
1 – 5 (micro)	2,43
6 – 20 (small)	3,19
21 – 100 (medium)	3,41
>100 (large)	3,38

4.2.7.3 Project Time Management

The maturity levels of each of the processes (except schedule development) are above the overall maturity level for the consulting engineering industry (which is 3.20). Schedule development has the lowest maturity, which could be due to the fact that not everyone has scheduling software. This results in practitioners resorting to basic charts using programmes like excel charts which do not allow the user to perform advanced scheduling functions.

Table 4-13: Maturity of time management processes

Process	**Maturity level**
a. Activity Definition	3,56
b. Activity Sequencing- Identifying and documenting interactivity dependencies.	3,39
c. Activity Duration Estimating	3,27
d. Schedule Development	3,17
e. Schedule Control	3,29
Average	**3,34**

Table 4-14 shows the average maturity values for time management for each firm size category. Again, results show that bigger organisations have higher maturity values than the smaller organisations.

Table 4-14: Maturity of time management by firm sizes

Size of firm	**Maturity level (1-5)**
1 – 5 (micro)	2,76
6 – 20 (small)	3,27
21 – 100 (medium)	3,35
>100 (large)	3,75

4.2.7.4 Project Cost Management

The maturity level of cost management is above the overall industry average of 3.2.

Table 4-15: Maturity of cost management processes

Process	Maturity level
a. Resource Planning	3,34
b. Cost Estimating	3,39
c. Cost Budgeting	3,37
d. Cost Control	3,17
Average	**3,32**

Table 4-16 shows the average maturity values for each firm category. Results show that bigger organisations have higher maturity values than the smaller organisations.

Table 4-16: Maturity of cost management by firm sizes

Size of firm	Maturity level (1-5)
1 – 5 (micro)	2,80
6 – 20 (small)	3,13
21 – 100 (medium)	3,35
>100 (large)	3,64

4.2.7.5 Project Quality Management

Respondents are most proficient at quality management than all the other knowledge areas. This could be due to the fact that more and more organisations are realising the benefits of having a quality system and most are either ISO 9001–certified or are working towards attaining certification. According to Industry Insight (2015:30) all firms are required to have a QMS as a condition of CESA membership and the majority of firms (96 %) reported to have a QMS system in place. While all the larger firms have the QMS in place, 90% of the micro enterprises currently comply.

Table 4-17: Maturity of quality management processes

Process	Maturity level
a. Quality Planning	3,61
b. Quality Assurance	3,61
c. Quality Control	3,54
Average	**3,59**

Also for most consulting projects the ECSA Guideline Scope of Services is used as a basis for scope of work. Most clients have standardised their contract documents. As a result, by using these already established documents, organisations, small and big, are by default practicing quality planning (for example; specifications, acceptance criteria), quality assurance (approvals and sign-offs during constructional) and quality control.

Results in Table **4-18** show that, contrary to the expectation that the larger the organisation the higher the maturity value, small organisations are more proficient at quality management than the medium organisations.

Table 4-18: Maturity of quality management by firm sizes

Size of firm	Maturity level (1-5)
1 – 5 (micro)	3,07
6 – 20 (small)	3,71
21 – 100 (medium)	3,51
>100 (large)	3,85

4.2.7.6 Project Human Resources Management

The average maturity of human resources management (2.97) is below the overall average for the consulting engineering industry (which is 3.20), and is the second lowest after risk management. The team development process has the lowest maturity.

Table 4-19: Maturity of human resource management processes

Process	Maturity level
a. Organization Planning	3,22
b. Staff Acquisition	3,05
c. Team Development	2,63
Average	**2,97**

Table **4-20** shows the average maturity values for HR management for each firm category. The micro (1-5 people) category has a much lower value, which could be ascribed to the fact that due to their size the firms do not have separate people dealing with human resource issues because of the small number of people employed.

Table 4-20: Maturity of human resources management by firm sizes

Size of firm	Maturity level (1-5)
1 – 5 (micro)	1,93
6 – 20 (small)	2,88
21 – 100 (medium)	3,16
>100 (large)	3,21

4.2.7.7 Project Communication Management

The maturity of communication management (3.24) is slightly above the average for the industry (which is 3.20). The “Performance reporting” process has the highest value.

Table 4-21: Maturity of communication management processes

Process	Maturity level
a. Communication Planning	3,20
b. Information Distribution	3,24
c. Performance Reporting	3,46
d. Administrative Closure	3,05
Average	**3,24**

Table **4-22** shows the average maturity values for communication management for each firm category. The large (>100 people) category has a lower maturity level than the small (6-20) and medium (21-100) categories. This is in contrast to the trend for most of the knowledge areas where bigger organisations are associated with higher maturity.

Table 4-22: Maturity of communication management by firm sizes

Size of firm	Maturity level (1-5)
1 – 5 (micro)	2,65
6 – 20 (small)	3,31
21 – 100 (medium)	3,37
>100 (large)	3,25

4.2.7.8 Project Risk Management

Survey results indicate that respondents are least proficient in risk management. It has the lowest maturity of all the ten knowledge areas. The "Risk Planning" process has the least maturity value. All the processes fall below the average maturity level of 3.20 for the consulting engineering industry.

Table 4-23: Maturity of risk management processes

Process	Maturity level
a. Risk Management Planning	2,59
b. Risk Identification	2,93
c. Qualitative Risk Analysis	2,85
d. Quantitative Risk Analysis	2,71
e. Risk Response Planning	2,68
f. Risk Monitoring and Control	2,61
Average	**2,73**

These results mirror findings by PMSA (2013:17) which showed that:

- Risk management had the lowest maturity of all the nine knowledge areas (2.79); and

- All the individual processes except “Risk Identification” fell below the average maturity level (which was 3.06).

Table 4-24: Maturity of risk management by firm sizes

Size of firm	Maturity level (1-5)
1 – 5 (micro)	2,17
6 – 20 (small)	2,52
21 – 100 (medium)	2,87
>100 (large)	3,20

Results in **Table 4.24** show that bigger organisations are much more proficient at risk management than the smaller organisations.

4.2.7.9 Project Procurement Management

Procurement management has the third highest score after quality- and time-management. There are very small gaps between the processes, with solicitation planning being the highest.

Table 4-25: Maturity of procurement management processes

Process	Maturity level
a. Procurement Planning	3,27
b. Solicitation Planning	3,22
c. Solicitation	3,49
d. Source Selection	3,24
e. Contract Administration	3,20
f. Contract Closeout	3,32
Average	**3,29**

Results in **Table 4-26** show that small organisations have a higher maturity value than the medium and large organisations, which is in contrast to the trend for most of the knowledge areas where bigger organisations are associated with higher maturity.

Table 4-26: Maturity of procurement management by firm sizes

Size of firm	Maturity level (1-5)
1 – 5 (micro)	2,70
6 – 20 (small)	3,50
21 – 100 (medium)	3,34
>100 (large)	3,43

4.2.7.10 Project Stakeholder Management

This is a knowledge area that was recently introduced in the 5th Edition of PMBOK® published in 2013. The maturity level is below the overall average for the industry indicating that the knowledge area is in its infancy.

Table 4-27: Maturity of stakeholder management processes

Process	Maturity level	
a. Identify Stakeholders	3,12	
b. Stakeholder Management	3,12	
c. Manage Stakeholder Engagement	3,20	
d. Control Stakeholder Engagement	2,90	
Average	**3,09**	

Table 4-28 shows the average maturity values for each firm category. The large (>100 people) category has the highest maturity level, but the medium (21-100) category has a lower level that the small (6-20) category. Again, this is in contrast to the trend for most of the knowledge areas where bigger organisations are associated with higher maturity.

Table 4-28: Maturity of stakeholder management by firm sizes

Size of firm	Maturity level (1-5)
1 – 5 (micro)	2,45
6 – 20 (small)	3,22
21 – 100 (medium)	3,19
>100 (large)	3,30

4.2.8 PMBOK® Guide Process Groups

The processes in the PMBOK® Guide are grouped into the following process groups:

a) Initiating processes
b) Planning processes
c) Executing processes
d) Monitoring and controlling processes
e) Closing processes

Tables 4-29 and **4-30** show that the maturity levels for the groups are close to each other, with the executing group being the highest (at 3.23) and the monitoring and controlling group the lowest (3.16).

Table 4-29: Mapping of process maturities (1 of 2)

Knowledge Areas and Processes	Process Groups				
	Initiating	Planning	Executing	Monitoring and controlling	Closing
Project Integration Management					
a. Initiation	3,29				
b. Project Plan Development		3,12			
c.Direct and Manage Project Work			3,37		
d.Integrated Charge Control				3,07	
e.Project / Phase Close-out					3,20
Project Scope Management					
a. Scope Management Planning		2,95			
b. Requirements Collection		3,17			
c. Scope Definition		3,56			
d. Create WBS		3,39			
e. Scope Control				3,20	
Project Time Management					
a. Activity Definition		3,56			
b. Activity Sequencing		3,39			
c. Activity Duration Estimating		3,27			
d. Schedule Development		3,17			
e. Schedule Control				3,29	
Project Cost Management					
a. Resource Planning		3,34			
b. Cost Estimating		3,39			
c. Cost Budgeting		3,37			
d. Cost Control				3,17	

Table 4-30: Mapping of process maturities (2 of 2)

Knowledge Areas and Processes	Process Groups				
	Initiating	Planning	Executing	Monitoring and controlling	Closing
Project Quality Management					
a. Quality Planning		3,61			
b. Quality Assurance			3,61		
c. Quality Control				3,54	
Project Human Resource Management					
a. Organisation Planning		3,22			
b. Staff Acquisition			3,05		
c. Team Development			2,63		
Project Communication Management					
a. Communication Planning		3,20			
b. Information Distribution			3,24		
c. Performance Reporting				3,46	
d. Administrative Closure					3,05
Project Risk Management					
a. Risk Management Planning		2,59			
b. Risk Identification		2,93			
c. Qualitative Risk Analysis		2,85			
d. Quantitative Risk Analysis		2,71			
e. Risk Response Planning		2,68			
f. Risk Monitoring and Control				2,61	
Project Procurement Management					
a. Procurement Planning		3,27			
b. Solicitation Planning		3,22			
c. Solicitation			3,49		
d. Source Selection			3,24		
e. Contract Administration				3,20	
f. Contract Closeout					3,32
Project Stakeholder Management					
a. Identify stakeholders	3,12				
b. Plan Stakeholder Management		3,12			
c. Manage Stakeholder Engagement			3,20		
d. Control Stakeholder Engagement				2,90	
Average for each process group	**3,21**	**3,18**	**3,23**	**3,16**	**3,19**

4.3 Testing of hypotheses

4.3.1 Hypothesis 1

By using a PMBOK® Guide-based maturity model, results of the maturity of project management processes in consulting engineering firms were obtained. The knowledge area summaries are shown in **Table 4-31** and are compared with results of other studies that have measured the maturity of project management in the Construction and Civil Engineering Industry.

Table 4-31: Comparison of maturities (this study vs previous studies)

	Maturity level (1 - 5)			
Knowledge area	**This study [1]**	**PMSA (2013)[2]**	**Pretorius et al (2012)[3]**	**Vester & Lazarus (nd)[4]**
Integration	3,21	3,02	-	-
Scope	3,25	3,03	-	-
Time	3,34	3,06	-	-
Cost	3,32	3,20	-	-
Quality	3,59	3,24	-	-
HR	2,97	2,83	-	-
Communication	3,24	3,01	-	-
Risk	2,73	2,79	-	-
Procurement	3,29	3,34	-	-
Stakeholder	3,09	-	-	-
Average maturity	**3,20**	**3,06**	**2.88**	**3.90**

[1] *Study conducted on consulting engineering firms in South Africa*

[2] *189 out of 218 projects surveyed were executed in South Africa. Respondents are from the Construction and Civil Engineering sector*

[3] *Study conducted on IT and Engineering companies in South Africa*

[4] *Study conducted on Engineering Consulting Firms in South Africa. Results are for the Project Management category of the broad study*

Results from studies by Pretorius et al. (2012) and Vester & Lazarus (nd) indicate the average maturity levels for the industries they investigated, whereas results by PMSA (2013) are decomposed into PMBOK® Guide knowledge areas and processes, in the same way this study was carried out. Results of this study will therefore only be compared with the PMSA (2013) study.

The first hypothesis intimates that the maturity of project management in Consulting Engineering firms is low when compared to the average in the engineering and construction industries in South Africa.

The result is that hypothesis 1 is not supported.

4.3.2 Hypothesis 2

The second hypothesis intimates that smaller firms have lower levels of project management maturity than the bigger firms.

The results of the study are summarised in **Table 4-32.** The results show that the average project management maturity increases as the firm size gets bigger.

Table 4-32: Summary of maturity for knowledge area vs firm size

	Firm Category			
	1 - 5 Micro	**6 - 20 Small**	**21 - 100 Medium**	**>100 Large**
Integration	2,04	3,28	3,34	3,56
Scope	2,43	3,19	3,41	3,38
Time	2,76	3,27	3,35	3,75
Cost	2,80	3,13	3,35	3,64
Quality	3,07	3,71	3,51	3,85
HR	1,93	2,88	3,16	3,21
Communication	2,65	3,31	3,37	3,25
Risk	2,17	2,52	2,87	3,20
Procurement	2,70	3,50	3,34	3,43
Stakeholder	2,45	3,22	3,19	3,30
Average maturity per firm category	**2,50**	**3,20**	**3,29**	**3,46**

The result is that hypothesis 2 is supported.

In this Chapter the results of the survey have been presented and discussed and the hypotheses have been tested. The next Chapter concludes the study with recommendations and the conclusion.

5 CHAPTER 5: RECOMMENDATIONS AND CONCLUSIONS

This chapter discusses the findings in relation to the objectives of the study, gives recommendations on areas that need improvement by consulting engineering firms and recommends areas of possible future studies.

5.1 Findings in relation to research objectives

The results of this survey may prove to be invaluable to CEFs. This chapter analyses the results to see if the objectives of the study have been met, provides a summary of the findings and offers recommendations to CEFs.

5.1.1 Maturity levels of consulting engineering firms

The primary objective of the study was to measure the project management maturity levels of consulting engineering firms, overall and for each project management knowledge area. The overall project management maturity was then compared with the average maturity level for the built environment professionals.

In order to calculate the project management maturity of each firm, maturity levels of the processes were determined through a survey. The maturity of each of the ten knowledge areas was then calculated. The maturity of a firm was then calculated as the average of the maturities of the ten knowledge areas.

There is limited data available on the project management maturity of consulting engineering firms. Studies by PMSA (2013), Pretorius et al. (2012) and Vester & Lazarus (nd) offer the closest benchmarking results for project management maturity levels for firms in the built environment. Only the PMSA (2013) study on the Construction and Civil Engineering (CCE) Sector gives the results for the ten knowledge areas and for comparison's sake, these are the only results used to benchmark the results of this study. The results are given in **Table 5-1.**

Table 5-1: Comparison of maturity levels of current study vs previous study

	Maturity level (1 - 5)	
Knowledge area	**This study (Consulting Engineering Firms)**	**PMSA (2013) (construction and civil engineering sector)**
Integration	3,21	3,02
Scope	3,25	3,03
Time	3,34	3,06
Cost	3,32	3,20
Quality	3,59	3,24
HR	2,97	2,83
Communication	3,24	3,01
Risk	2,73	2,79
Procurement	3,29	3,34
Stakeholder	3,09	-
Average maturity	**3,20**	**3,06**

Overall, the CEFs have higher levels of project management maturity than the average for the construction and civil engineering sector. Apart from risk and procurement management, all the other knowledge areas also have higher maturity levels than the corresponding construction and civil engineering knowledge areas. Stakeholder management results are not included in the PMSA (2013) study, presumably because the study was done before the 5th edition of the PMBOK® which was published in 2013.

5.1.2 Relation between PMM levels and sizes of CEFs

The first secondary objective was to identify the relationship between the project management maturity levels and the size of the consulting engineering firms.

Results of the study show that overall the bigger the consulting engineering firm the higher the level of project management maturity. This relationship is only true for the integration, time, cost, HR and risk knowledge areas. The maturity

levels for quality management and stakeholder management are higher in the small (6-20 persons) firms than the medium (21-100 persons) firms. For scope and communication management, the maturity levels are lower for the large firms than for the medium firms.

Although the individual knowledge areas are inconsistent, the overall maturity results indicate that the larger firms are more mature in their project management practices than the smaller firms.

5.2 Recommendations

The study reveals that consulting engineering firms are weakest in the following knowledge areas:

a) Risk management
b) HR management and
c) Stakeholder management.

Risk processes are not identified as causing shortcomings in the delivery of projects, unlike HR. Stakeholder management was only introduced as a knowledge area in the 5th edition of the PMBOK® Guide in 2013.

The knowledge areas which contain the processes that are cited by most authors as causing project failures or shortcomings are Cost-, Time-, HR-, Scope- and Integration management. Of these, the order of their maturity, starting from the lowest, is; integration, scope, cost, time.

The lowest-scoring processes, whose maturity affects the outcome of projects, need to be improved by CECF's. These are:

- **Integration:** integrated change control, project plan development
- **Scope:** scope management planning, requirements collection
- **Time:** schedule development, activity duration estimation
- **Cost:** Cost control,

5.3 Future research

There is limited literature available on the status of project management, project management methodologies, and performance of consulting projects in the engineering environment (Labuschagne & Steyn, 2010:70). As a result of this, all measurements of maturity that have been carried out so far on CEFs have been based on generic maturity models most of them modelled around the PMBOK® knowledge areas. Although the maturity models are applicable from the point of view that the majority of skills that need to be applied effectively by CEFs in order to achieve positive results can be attributed to the PMBOK® knowledge areas, there is need for future studies to establish:

(a) A methodology developed specifically for the Consulting Engineering Firms in line with what Labuschagne & Steyn (2010) started;
(b) A Project Management Maturity Model specific to the Consulting Engineering Industry.

5.4 Conclusion

The study investigated how effectively consulting engineering firms are applying project management principles in the way they manage projects. The project management maturity of consulting engineering firms was compared with results of a similar study and the conclusion was that the level of project management in the firms is higher than the average for the Construction and Civil Engineering Sector. The relationship between the project management maturity levels and the size of the consulting engineering firms was also investigated. Although the individual knowledge areas are inconsistent, the overall maturity results indicate that the larger firms are more mature in their project management practices than the smaller firms. Recommendations have been made on processes where consulting engineering firms are performing the lowest. The research results will be used as a source of benchmark data for future studies.

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APPENDICES

Appendix 1:

Survey Questionnaire

Survey Questionnaire for:

Assessment of Project Management Maturity in Consulting Engineering Firms

The questionnaire consists of the following parts:

Part 1:	Details of your organisation
Part 2:	Project Retrospection – assessing the perceived success of the recently completed projects
Part 3:	Project Management Maturity – questions on PM processes

Part 1: Details of your organisation

1.	**Size of organisation in which you work**	0-5	6-20	21-100	>100
	How many employees does your organisation count?				

2.	**Project management office**	YES	NO
	Does a formal project management office (PMO) exist in your organisation?		

Part 2 Project Retrospection

For the purposes of this study the three categories of project outcome are defined as follows:

- **Failed:** A project that is never completed or does not meet customer requirements. It delivers very little or no value at all.
- **Challenged:** A project that is completed, but is late, over budget, or does not meet all the requirements. It delivers moderate value: less than what was anticipated.
- **Successful:** A project that is delivered on time, within budget, within scope, and complies with the quality requirements. It delivers strong value; the expected value.

1	**Total** number of projects completed in last 12 months by your organisation	
2	Number of **successful** projects in last 12 months.	
3	Number of **challenged** projects in last 12 months.	
4	Number of **failed** projects in last 12 months.	

Part 3: Project Management Processes

Please consider the following definitions carefully before completing Part 3 questions. The following definitions refer to the maturity levels in questions in Part 3.

Maturity Level 1 – Initial Process

- **Process** – No established practices and standards
- **Documentation** – Loose and ad-hoc.
- **Management** – Management understands the definition of a project, and is aware of the need for project management
- **Metrics** – collected information on an ad-hoc basis.

Maturity Level 2 – Structured Process and Standards

- **Processes-** Processes exist, but are not considered an organizational standard.
- **Documentation** – Documentation exist on the basic processes.
- **Management** – Management supports the implementation of project management, but understanding and involvement is not consistent / applied to all projects. Large projects are executed in a systematic fashion, and management is involved in such projects.
- **Metric**s – Basic metrics to track cost, schedule and technical performance exist.

Maturity Level 3 – Organizational Standards and Institutionalized Process.

- **Process** – All project management processes are in place and established as organizational standards. These processes involve the clients as members of the project team. Nearly all projects use these processes.
- **Documentation** – Documentation exist on all the processes
- **Management** – Management is regularly involved in input and approval of key decisions.
- **Metrics** – Metrics are formally collected and each project is evaluated and managed in light of other projects

Maturity Level 4 – Managed Project.

- **Processes** – project management processes, standards and supporting system are integrated with other corporate processes and systems.
- **Documentation** – Processes and standards are documented to support using metrics to make project decisions
- **Management**- Management understands its role the project management process. There are difference management styles and project management requirements for different projects.
- **Metrics** – Efficiency and effectiveness metrics are used. All projects, changes and issues are evaluated based upon metrics from cost estimates, baseline estimates

and earned value calculations.

Maturity Level 5 – Optimizing Process

- **Process** – Processes are in place and actively used to improve project management activities.
- **Documentation** – Lessons learned are regularly examined and used to improve project management processes, standards and documentation.
- **Management** – Management is focused not only effectively managing projects but also on continuous improvement.
- **Metrics** – The metrics collected during project execution are used to understand the performance of a project and to assist in the making of organizational management decisions for the future.

This section contains 45 questions. Please rate each of the following statements according to the maturity levels on the previous page, by making an X in the appropriate box. If your organization does not implement a specific section, please mark the N/A (not application) box.

1.	**Overall Level of Maturity**	1	2	3	4	5
a.	What do you think the overall level of project management maturity is in your organization?					

2.	**Project Integrated Management**	N/A	1	2	3	4	5
a.	**Project Plan Development** Integrating and coordinating all project plans to create a consistent, coherent document.						
b.	**Project Plan Execution** Executing the project plan by performing the activities included therein						
c.	**Integrated Charge Control** Coordinating changes across the entire project.						

3.	**Project Scope Management**	N/A	1	2	3	4	5
a.	**Initiation** Authorizing the project or phase.						
b.	**Scope Planning** Developing a written scope statement as the basis for future project decisions						
c.	**Scope Definition** Subdividing the major project deliverable into smaller, more manageable components						
d.	**Scope Verification** Formalizing acceptance of the project scope.						
e.	**Scope Change Control** Controlling changes to project scope.						

4.	Project Time Management	N/A	1	2	3	4	5
a.	**Activity Definition** Identifying the specific activities that must be performed to produce various project deliverables.						
b.	**Activity Sequencing** Identifying and documenting interactivity dependencies.						
c.	**Activity Duration Estimating** Estimating the number of work period that will be required to complete individual activities.						
d.	**Schedule Development** Analyzing activity sequences, activity durations and resource requirements to create the project schedules						
e.	**Schedule Control** Controlling changes to the project schedule.						

5.	Project Quality Management	N/A	1	2	3	4	5
a.	**Quality Planning** Identifying which quality standards are relevant to the project and determining how to satisfy them.						
b.	**Quality Assurance** Evaluating overall project performance on a regular basis to provide confidence that the project will satisfy the relevant quality standards						
c.	**Quality Control** Monitoring specific project results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance.						

6.	Project Human Resource Management	N/A	1	2	3	4	5
a.	**Organization Planning** Identifying, documenting and assigning project roles, responsibilities and reporting relationships.						
b.	**Staff Acquisition** Procuring the required human resources and assigning it to the project.						
c.	**Team Development** Developing individual and group competencies to enhance project performance.						

7.	Project Cost Management	N/A	1	2	3	4	5
a.	**Resource Planning** Determining what resources and what quantities of each should be used to perform project activities						
b.	**Cost Estimating** Developing an estimate of the costs of the resources required to complete project activities.						
c.	**Cost Budgeting** Allocating the overall cost estimate to individual work activities.						
d.	**Cost Control** Controlling changes to the project budget						

8.	Project Communication Management	N/A	1	2	3	4	5
a.	**Communication Planning** Determining the information and communications needs of the stakeholders..						
b.	**Information Distribution** Making required information available to project stakeholders in a timely manner.						
c.	**Performance Reporting** Collecting and dissemination performance information. This includes status reporting, progress measurement, and forecasting.						
d.	**Administrative Closure** Generating, gathering, and disseminating information to formalize a phase or project completion.						

9.	Project Risk Management	N/A	1	2	3	4	5
a.	**Risk Management Planning** Deciding how to approach and plan the risk management activities for a project.						
b.	**Risk Identification** Determine which risks might affect the project and documenting their characteristics.						
c.	**Qualitative Risk Analysis** Performing a qualitative analysis of risks and conditions to prioritize their effects on project objectives.						
d.	**Quantitative Risk Analysis** Measuring the probability and consequences of risk and estimating their effects on project objectives.						
e.	**Risk Response Planning** Developing procedures and techniques to enhance opportunities and reduce threats to the project's activities						
f.	**Risk Monitoring and Control** Monitoring residual risk, identifying new risks, executing risk reduction plans and evaluating their effectiveness throughout the project life cycle.						

10.	Project Procurement Management	N/A	1	2	3	4	5
a.	**Procurement Planning** Determining what to procure and when.						
b.	**Solicitation Planning** Documenting product requirements and identifying potential sources.						
c.	**Solicitation** Obtaining quotation, bids, offers, or proposals, as appropriate.						
d.	**Source Selection** Choosing from among potential sellers.						
e.	**Contract Administration** Managing the relationship with the seller.						
f.	**Contract Closeout** Completion and settlement of the contract, including resolution of any open items.						

11.	Project Stakeholder Management	N/A	1	2	3	4	5
a.	**Identify stakeholders** Identifying the people, groups, or organizations that could impact or be impacted by a decision, activity, or outcome of the project.						
b.	**Stakeholder Management Planning** Developing appropriate management strategies to effectively engage stakeholders throughout the project life cycle, based on the analysis of their needs, interests, and potential impact on project success.						
c.	**Manage Stakeholder Engagement** Communicating and working with stakeholders to meet their needs/expectations, address issues as they occur, and foster appropriate stakeholder engagement in project activities throughout the project life cycle.						
d.	**Control Stakeholder Engagement** Monitoring overall project stakeholder relationships and adjusting strategies and plans for engaging stakeholders.						

12	**Results of survey**	YES	NO
	Do you want to receive an overview of the results of this survey by email?		
	If yes, write your email address below:		

This is the end of the survey. Thank you for your participation!

Appendix 2:

The Krejcie and Morgan Table of determining sample size for finite population.

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size. *S* is sample size.

Source: Krejcie & Morgan, 1970